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EPHEMERA, THE MAY-FLY.

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(*With Two Plates.*)

Let us fancy ourselves on the banks of a trout-stream about the end of May or the beginning of June, for it is too late in the year, now that October leaves are beginning to fall, to look for any species of the May-fly family, unless, perhaps, one may discover some small members of the group, such as the little Blue and Pale Duns, *Baëtis* and *Cloë*, which love to dance in the sunny days of a calm autumn.

What a lovely morning for a day's fly-fishing! I'll be bound the green-drake will be on the water in the course of the day, so let us start at once, with rod and basket in hand, and let us not forget a few collecting bottles, and a net—not for the fish, but for the May-flies; for angler-naturalists, you may be sure, never set out on a fishing expedition without collecting bottles and gauze nets.

> "Our art can tell the insect tribe that every month doth bring,
> And with a curious wile we know to mock its gauzy wing;
> We know what breeze will bid the trout through the curling waters leap,
> And we can surely win him from shallow or from deep;
> For every cunning fish can we a cunning bait provide,
> In the sport, that we court, by the gentle river tide."*

Well, it is disappointing certainly, wind in the south-west, sun nicely overcast, green-drake coming out, but, alas! the water is as shallow as can be. No sport at present, that is certain. The miller has pounded up the water three miles up stream, and till old Flour-dust begins to grind it is useless whipping an almost empty river. Perhaps if we wait quietly a couple of hours the water will come down, and we may yet kill a good basket of fish; so let us console ourselves with a pipe of tobacco, and occupy our time with observing the May-

* *New Sporting Magazine*, v. 20.

flies. See how fast the green-drake is appearing. Notice how it flies, with head erect for a second or two, and then falls almost helplessly on the surface of the water. There! a fish rose at him, did you see? But *Ephemera* has escaped the cavernous jaws of a trout, and now has succeeded in reaching a blade of grass, where he will probably rest for some hours. It is mid-day now, and still the green-drake comes out. Let us lie flat down on the bank, where the water is smooth and free from rapids, and I dare say we shall discover *Ephemera* in the very act of emerging from his nympha state. Here comes something floating down. It is within reach of my hand, so I will secure it. What is it? It is as I thought. *Ephemera* is throwing off his swaddling-clothes. See how he twirls and twists the last portion of his body about, already free. There is a split in his back; through it he will presently draw out his head.* Sometimes, instead of leaving his swaddling-clothes in the water, he deposits them on a blade of grass, or some water-weed.

Let us capture a number of these green-drakes, and take them home for dissection. Now, observe that these green-drakes are not all of the same size, some being larger and fatter than others. The small ones are the males, and the large ones the females; but we must remember that both large and small specimens have not yet arrived at maturity. They have cast off their upper clothes, it is true, but there is still an under suit which they will get rid of. But they are only children at present. I must here express my surprise at assertions not unfrequently made in some natural history books, that the *Ephemera*, in its green-drake stage, deposits eggs. The latest repetition of this error which I have seen is in Mr. Cholmondeley Pennell's book, *The Angler Naturalist*, in which he says, at p. 331: "When the time arrives for the transformation of the loathsome grub into the brilliant and delicate May-fly, the insect crawls up from the mud in which its hole is bored, by the stem of the nearest rush or water weed, on which it rapidly casts the disfiguring slough, dropping its eggs into the water as it rises from the surface for its first flight." When we consider how many anomalous circumstances do occur in the animal world, such, for instance, as *Parthenogenesis*, and reproductive larvæ, it would, perhaps, be speaking too confidently to affirm that something analogous to this never occurs in the case of *Ephemera vulgata*; but until such a thing is substantiated by positive proof, we must consider the immature *sub-imago* of the May-fly to be no exception to the general rule.

* These insects often draw out the anterior part of the body first, and sometimes the tail part, or abdomen, appears first.

What numbers of May-flies in their imperfect condition fall victims to the hunger of trout and other fish! Being heavy fliers in their sub-imago state—for their wings are scarcely dry, and their muscles unequal as yet to any great exertion—they are constantly dropping for a second or two on the water, and are then sucked down the throat of some trout, roach, or dace that is constantly on the look-out.

Let us now follow the green-drake to the spot where he has rested. Here he will remain for the space of two or three hours, perhaps, and then will be introduced to the world of life as an adult and perfect insect. Look at this blade of grass. What is the shadowy form that clings to it? It is a delicate membrane, thin and light as possible, which the slightest breath will blow away. Notice the split across the back, through which the former tenant left his abode. It is the cast-off skin of the green-drake, now metamorphosed into a creature more active than Harlequin or Columbine,—the male into a dark-brown insect, with clear and gauze-like wings, the female into a beautiful creature, with body marbled white and brown. How different now is the mode of flight! But, alas, "out of the frying-pan into the fire." The flies are partly safe from Scylla, but they fall into Charybdis; for birds of various kinds, swallows, swifts, tomtits, larks, chaffinches, and a host of other feathered enemies, are on the watch, seeking the dainty morsels to feed themselves or their hungry young. See now how curious is the dance they practise. Up and down, up and down! with head erect, and bodies prettily curving upwards, dancing in the sun, which now shines out from beneath the clouds—merrily, merrily! Truly an *Ephemera's* life has many "ups and downs," and the insects doubtless enjoy them immensely.

But we must here notice that it is the males that execute this particular style of dance, rising up sometimes ten or twelve feet, then dropping down suddenly the same distance. At least I am inclined to think this dancing is confined to the gentlemen; for I have never yet detected a lady, in her white and marble dress, amongst the company. The flight of her ladyship differs considerably now from what it was before she cast her last garments away. No longer a clumsy, helpless mode of flying, sustained with much difficulty; but a swift, strong flight, not unlike that of the dragon-fly, is that of the perfect Ephemeral imago. Now high in the air, now sailing along close to the surface of the water, ever and anon dipping gently into it, she is evidently busy discharging some important duty. She is laying her eggs, by little packets at a time, first in one place and then in another. The small oval eggs sink quickly down to the bottom, and attach themselves to submerged weeds and stones. This is the sole object of her life, now that she has become a mother;

not a particle of food has she tasted since she left her nymphal state, not a particle of food will she taste so long as her short life lasts. If you examine the digestive apparatus of any of these insects, whether male or female, when in the imago or sub-imago state, you will never find the slightest traces of food in the stomach; this organ, as well as the whole intestinal canal, is almost always full of air-bubbles; catch one of those dancing males with their long extended fore-feet that you may mistake for antennæ, and press him quickly in the middle, crack he goes! for the little air-bubbles have burst by the pressure. No wonder that Ephemera's stomach is empty, for he has no mouth, at least none that could be of any use to him, so rudimentary is that organ now. But though his stomach is full of air-bubbles, we must not suppose that Ephemera suffers in the least from flatulence. The intestinal canal, there can be no doubt, serves the purpose of buoying up the little animal, and saves the expenditure of muscular action; for as no food is taken to supply the waste, the muscles will not be capable of long-sustained action. But see the water is now coming down beautifully; bravo old Flour-dust! Now for the fly-rod. There's a fish just under that stone where the current forms a quiet back eddy, I'll be bound to say. And I have him now, and a good fish he is! Now for the landing-net, for the bank is steep. Well done! He is a good pound-weight, and in nice condition. Just let us open his stomach, and see what he has had for dinner. We must float the contents out into a little water, and now we find a quantity of green-drakes, with a promiscuous variety of other insect food. We will still, therefore, keep to our artificial May-fly.

And now having killed a good basket of trout, we will return home with our specimens, and examine them with the aid of our dissecting scissors, and lens, and microscope. But before we do this, let us say a few words on *Ephemeridæ*, or the May-fly family in general.

The earliest notice of these insects occurs in Aristotle's *History of Animals*. In book v., chap. 18, he speaks of certain capsules larger than grapeseed floating down the river Hypanis in the Cimmerian Bosphorus about the time of the summer solstice, out of which, when ruptured, proceed four-footed winged creatures, which live and fly about till evening, and die at sunset, living but a day, for which cause the insect is called *Ephemeron*, the name by which it is known to this day. What the philosopher's grapeseed capsules may be I cannot say. It is evident that Aristotle was relating what he had heard from other sources, but there can be no doubt that the insect alluded to is some species of Ephemera. Œlian, who generally copies

Aristotle, speaks of the same insect under the name of *Monêmeron.** Scaliger, in his commentary on Aristotle's *History of Animals*, remarks that numbers of Ephemeræ are occasionally observed flying about the Garonne and Tarn, where they are commonly known by the name of Manna, from the fact of their forming an abundant food for the fish. Moufet, in 1634, speaks of certain genera of Ephemeræ, which possess two caudal setæ only, under the name of *Dittotriches* (διττότριχες)†. But none of these writers appear to have given much attention to the natural history of this interesting family of Neuropterous insects. It was reserved for the illustrious Dutch naturalist, Swammerdam, to make known to the world most of the wonders of ephemeral life. His observations have, for the most part, been verified by Reaumur and De Geer (1742 and 1745); Scopoli, Kirby, Burmeister, Stephens, and Pictet, are names well known to all engaged in the study of the Ephemeridæ.

In our own country, the May-flies appear about the end of May and the beginning of June, and continue for about three weeks. The green-drake issues from his nymphal state almost at any hour in the day, but especially when the sun is shining. In Sweden, the birth of these insects is confined nearly to the evening, about sunset; but it is quite an error to assert that our British *Eph. vulgata* emerges from the water only in the evening.‡ Some species of Ephemeridæ appear in the most astonishing swarms, in some parts of Europe. Scopoli tells us, that so great an abundance of *Eph. vulgata* sometimes occurs near the Lake Laz, in the month of June, that the inhabitants of the district are quite disappointed if they do not collect twenty cartloads of insects for manure! "Between the 10th and 15th of August is the time when those of the Seine and the Marne, which Reaumur described, are expected by the fishermen, who call them *manna;* and when their season is come, they say, "The manna begins to appear; the manna fell abundantly such a night"—alluding, by this expression, either to the astonishing quantity of food which the Ephemeræ afford the fish, or to the large quantity of fish which they then take." These immense swarms of Ephemeridæ have been noticed in Holland, Switzerland, and France, and have been compared to falling flakes of snow. "The myriads of Ephemera which filled the air," says Reaumur, "over the current of the river, and over the bank on which I stood, are neither to be expressed nor conceived. When the snow falls with the largest flakes, and with the least interval between them, the air is not so full of them as that which surrounded the Ephemeræ." The

* From μόνος, "alone," or "single," and ἡμέρα, "a day."
† That is, "two tails," or "hairs."
‡ W. S. Dallas in *Orr's Circle of the Sciences*, Organ. Nat. ii., p. 365.

occurrence of such countless swarms of Ephemeridæ is unknown in the British Isles.

The term *Ephemera*, so applicable to this creature of a day, must not be understood in too restricted a sense. It is quite true that numbers are devoured by fish or bird before they assume their final change, and that survivors have but a very brief existence. After the laying of the eggs, which, however, may last more than a single day, the female perishes, or dies a natural death. The only business of her life being accomplished, she has now only to die. If, however, a specimen be caught, and kept in confinement, and the laying be thus checked, an Ephemera may live several days. Whether the males are as short-lived as the females, I am unable to say; but I think it not improbable that they may survive somewhat longer, though, from the fact of their taking no food, it is probable that the life of all the Ephemeræ is of a very short continuance.

The family of Ephemeridæ consists of several genera, and their study will amply repay the observer. It is almost impossible to conceive any creatures more exquisite than some of the small kinds belonging to the genera *Baëtis*, *Cloë*, and *Cœnis*. The genus *Ephemera* is characterized by having three nearly equal caudal setæ in both male and female; these appendages are longer in the male, which is also readily distinguished from the female by its possessing two curved, clasping organs (Fig. D, *a*), longer fore-feet and setaceous tail appendages. The colour of the male of *Eph. vulgata* is much darker than that of the female, being bronze or chocolate; the male is also much smaller.

There is another species of Ephemera besides *E. vulgata*, the male of which I have occasionally met with in May and June. It is often, no doubt, mistaken for the female of the *E. vulgata*, which it much resembles in colour. It may often be seen in companies executing the characteristic dance. It does not agree with the description of *E. cognata* of Stephens, nor with Pictet's *E. danica*. There is also a fly known to anglers as the mackerel, a dark brown Ephemera: the colour is said to be the same both in the male and female. I have not been able to ascertain what species it is.

The eggs, after having been deposited in the water, sink to the bottom, and change into a small larva; in this state it is said to live for two or three years, and then to change to the *nympha* (Fig. B). Both in its larval and nymphal condition, the creature eats. The intestinal canal contains numerous algæ spores, small crustacea, rotifera, etc.

The larvæ and nymphæ are often found in holes in the river banks, and frequently also in the sand or mud at the

bottom of the water. The only difference between larva and nympha is that the latter has sheaths for the wings, which are rolled or crumpled up inside them. The banks of rivers may often be seen to be completely riddled by these larvæ, which tunnel for themselves tubular galleries in the mud to the depth of four or five inches. The larvæ of some other members of the Ephemeridæ, instead of living under the sand, or in tubular galleries, swim from place to place, as in the genus *Cloë*, while others crawl on the ground and on aquatic plants. The abdomen of the larva and nympha of *Ephemera vulgata* is bordered on either side by a row of gills which, by their constant motion, serve to draw fresh currents of water to oxygenate the blood. Each gill consists of two large tracheal trunks, in which smaller air vessels ramify in all directions (Fig. N). In the imago state the whole respiratory organization is changed, the tracheal trunks or gills are cast aside, and the insect now breathes by means of stigmata.

The dissection of the insect is a matter of some difficulty, owing to the extreme delicacy of the organs. The alimentary canal consists of a short œsophagus, stomach with rudimentary hepatic vessels, and intestine with its numerous renal or urinary vessels.

The stomach (*ventriculus*) is long and cylindrical, marked by several constrictions. In the sub-imago state it is surrounded by a distinct mass of secreting vessels of a very irregular form, which contain numerous curious bodies, circular in form, marked by concentric lines. These concentric lines seem to show that the bodies are formed of fine threads coiled one over the other, the thick end, in shape something like the head of a snake, being free (Figs. I, J, K).

In the imago state, these vessels have undergone a change of form. Instead of the irregular mass spoken of above we find now several membranous filaments attached to the outer walls of the stomach and intestine, with the same enclosed circular bodies. What can be the use of these bodies I cannot guess, nor am I acquainted with anything at all similar to them in any other insect. The side view of these bodies will remind the reader of certain forms of Diatomaceæ, such as *Naviculæ* and *Fragillaria*, etc. The lower portion of the intestine is surrounded by a tangled mass of threads as fine as a spider's web. These are numerous distinct vessels which empty themselves a little above the anus. Fig. M represents two of these vessels magnified.

The ovaries (Fig. G) consist of two almond-shaped organs, which occupy nearly the whole of the abdominal cavity. The ova are unattached, and readily separate themselves in water. It is the possession of these ovaries that makes the insects such

fat delicacies for the hungry fish which feed on them. The eggs are deposited, it is probable, in small clusters; certainly not all at once, as some writers have asserted.

Mr. Griffiths (*Anim. King.*, Insects ii. 321) tells us that "each Ephemera has seven or eight hundred eggs to lay, which is an affair of a moment, for she puts forth the two clusters at once" (!).

Swammerdam supposed that the eggs of the female were fertilized by the male at the moment of expulsion in the water, after the manner of fish; but there is doubt that the Ephemera does not differ from what obtains amongst other insects in this particular point.

The *Ephemeridæ* have all very short awl-shaped antennæ, hence the term *Subulicornes* proposed by Latreille, and very small hinder wings. In the genus *Cœnis* and in *Cloë diptera* the hind wings are entirely absent. The eyes are large; those of the male of *Ephem. vulgata* are much more prominent than the eyes of the female; the ocelli are three in number.

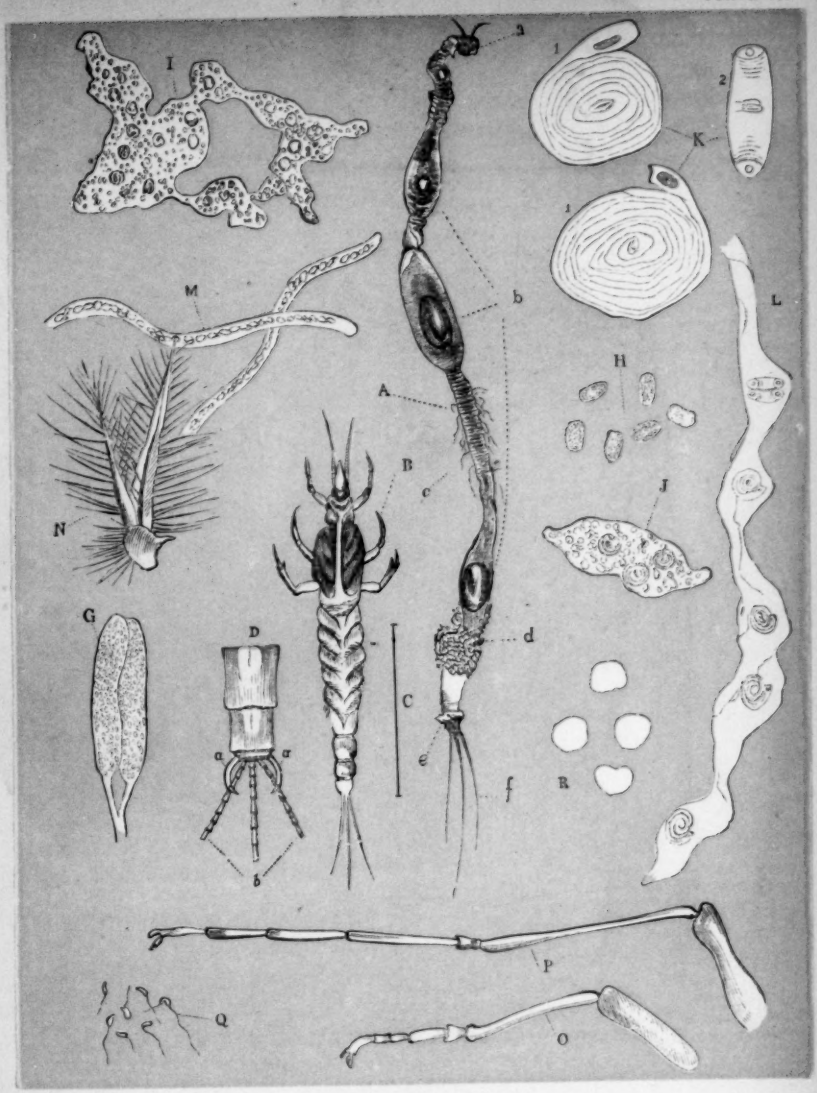
The term May-fly is very indefinite, standing for all sorts of different insects in different counties; here, in Shropshire, we generally restrict the word to the *Ephemera vulgata*. Anglers are often very positive that the green and grey drake are produced from the caddis worms, so abundant in every stream and pond, which are the larvæ of various kinds of *Phryganidæ*.

As the term *Cadow* is used to denote the May-fly (Ephemera), it is probable that the name was given to it under the mistaken notion that it was produced from a case larva.

That the grey-drake is only the female green-drake metamorphosed, or rather after the last pellicle is cast, may be sometimes readily proved by dissection. The marble and white skin of the female grey-drake may be seen by carefully slitting open or peeling off the first integument of the green-drake.

The expressions green and grey *drakes*, as applied to the May-flies by anglers, owe their origin to the fact that the wings of the artificial fly are made from a mallard's feather, dyed olive for the green-drake, or immature condition of the insect; and from the same feather slightly stained with purple for the grey-drake, or perfect form of the female.

The figure on the left-hand blade of grass in Plate I. represents the female green-drake, which changes into the grey-drake, seen resting on the right-hand blade, leaving her cast-off pellicle upon the grass stem, as seen in the engraving. The flying insect is the perfect male.



THE MAY FLY.—GREEN AND GREY DRAKE.

(Ephemera vulgata.)

A.—Digestive apparatus of Ephemera (magnified.) *a*, Head. *b*, Portions of digestive apparatus, inflated with air-bubbles. *c*, Stomach, with rudimentary biliary tubes. *d*, Entangled mass of secreting organs generally called renal. *e*, Anus. *f*, Caudal setæ. G, Ovaries, (magnified.) H, Ova, (mag. 20 diam.) I, Portion of biliary vessel in immature (sub-imago) insect, shewing curiously shaped bodies marked with concentric lines, (magnified.) J, Small portion of ditto more highly magnified. K, The curious organs (1, front view, 2, side view) resembling forms of Naviculæ, mag. 400. L, Membranous biliary filament in perfect insect (imago) containing the above-named bodies, mag. 200. M, Single renal vessels. N, External respiratory organ of nympha. O, Front leg of female imago. P, ditto of male. Q, Spermatozoa. R, Blood corpuscles, highly magnified. B.—Nympha of Ephemera vulgata, (magnified.) C.—Nat. size.

D.—Under side of last segments of male imago, shewing, *a*, clippers, and position of setaceous appendages at *b*.

THE THREAD-MOSSES.

BY M. G. CAMPBELL.

THE thread-mosses are an interesting and numerous tribe, containing upwards of fifty species, which have been parcelled out into eight distinct genera; but as space would fail us to describe them all, we shall, at the present time, only pass in review a portion of the *Bryums*, the chief genus.

They appear to derive their generic appellation from the Greek word *βρῦον, a moss*, which would seem to say they were the first of this tribe of plants that attracted attention, and we can scarcely wonder at this when we behold their dense tufts crowned with innumerable beautifully-formed reddish or bright brown pendulous capsules, like eardrops of cornelian or coral awaiting some fairy hand to give them a golden setting; at all events the name is of very ancient origin, is found in the works of Dioscorides, the Sicilian physician, and has been applied by Dillenius to this genus and its affinities.

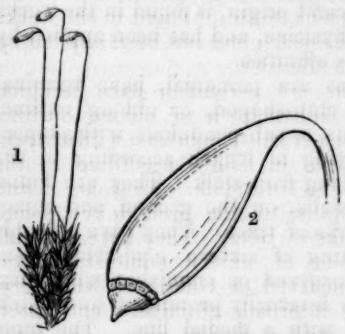
The mosses of this genus are perennial, have terminal fructification, of a pyriform, club-shaped, or oblong outline, smooth and inclined, pendulous, or sub-pendulous, with a tapering neck or apophysis, varying in length according to the species, and terminating a long fruit-stalk. They are found growing on rocks, on stone walls, on the ground, and sometimes, but rarely, on the trunks of trees. They have a double peristome, the outer consisting of sixteen equidistant, lanceolate, hygroscopic teeth, incurved or connivent when dry, transversely barred, the bars internally prominent, and externally the teeth are marked with a medial line. The inner peristome is a membrane divided half way down into sixteen carinate processes, alternating with the outer teeth. Sometimes furnished with, and sometimes destitute of, intermediate cilia, which when present are filiform, and either solitary or two or three together.

The spores are rather small, smooth, globular, green, or reddish brown. The stem has innovations from the floral apex, which innovations resemble the parent stem, are either simple or branched, are tomentose with radicles, and by their issuing from the floral apex, instead of from the lower part of the stem, form, though not without an exception, one of the characteristic differences between the species apportioned to this genus and those assigned to the *Mniums*.

One of the most common examples of this family is the *Bryum intermedium*, or *many-seasoned thread-moss*, which

may be found in fruit from June to December, on walls and rocks, in sandy, clayey, or gravelly places; and it is remarkable for continuing to ripen its fruit in the same tuft at successive periods.

The illustration is somewhat larger than the natural specimen, and the single capsule considerably magnified, with its lid just starting and showing a portion of the teeth. The stems when growing vary from two lines to half an inch in length, the barren branches being elongated, slender, and flagelliform, the rest shorter and fastigiate. The leaves are imbricated and erect, more or less spreading, and scarcely crisped when dry; the lower ones are reddish, all of them ovate acuminate, somewhat concave with a reflexed margin, which is sometimes denticulated, and an excurrent nerve. The inflorescence is synoicous, bearing both antheridia and archegonia on the same receptacle. The symmetrical capsule, is, as will be seen by the cut, narrowly pyriform, pendulous, or sub-pendulous, with a long neck and rather a small mouth, surrounded by a reddish or purplish border, not becoming constricted below the mouth when dry, and having the lid, which is more or less apiculate, and the annulus sub-persistent, or remaining on longer than in the allied species.



1, Bryum intermedium; 2, magnified capsule.

Bryum argenteum, or the *silvery thread-moss*, is also an easily met with species. It fruits in October and November, and is at home almost anywhere, on the ground, by the waysides, on walls, or on roofs of houses, compacting its slender and fragile stems, of from a quarter of an inch to an inch long, into exquisite silvery white patches; the lower leaves scattered, broadly ovate and apiculate, the upper ones ovate, or ovate-lanceolate, all of them very concave and imbricated, mostly apiculate, entire, not recurved in the margin, the nerve ceasing considerably beneath the point, the points colourless and more or less reflexed, and the areolæ lax.

The oval oblong capsule is attached to a fruit-stalk of about half an inch in length, which is suddenly bent at its junction with the capsule, and the latter is of a purplish or reddish colour when fully ripe, and becomes constricted below the mouth in the dry state, its convex lid obscurely pointed, and

its neck not tapering, but abruptly passing into the fruit-stalk, beautifully symmetrical and pendulous.

Bryum Zierii, or the *Zierian thread-moss*, also ripens its fruit in October and November. It grows in the crevices of rocks on the mountains of England, Scotland, Wales, and Ireland, planting them with its soft, pale, or silvery reddish, rather lax tufts, composed of stems from half an inch to an inch long, with julaceous, or slender glossy branches, whitish above and reddish below, somewhat resembling the last species in aspect, but larger, and always having a considerable tinge of red; the leaves are imbricated, roundish ovate in form, very concave, acuminate, entire, the margin not reflexed, but the apex, below which the nerve ceases, slightly recurved, the leaves of thin, membranous texture, the lower ones reddish, the upper longer and narrower, with the nerve extending nearer to the apex, and the reticulation loose. The capsule is more or less cernuous, large, of a reddish brown colour, clavato-pyriform, and gibbous on the upper side, with a long, tapering incurved neck, rendering the mouth oblique. The small conical, acute lid covers an unequal peristome, the inner being longer than the outer, and having only rudimentary cilia, or none at all; the spores are rather large and brownish, and the mouth of the capsule, tenacious of its nurslings while within the enclosure, becomes enlarged after their exit. The fruit-stalk is arcuate at the summit, and scarcely half an inch in length. Its more robust size, large and singular capsule, with the vinous hue of its foliage, sufficiently distinguish this interesting species from its nearest ally, *B. argenteum*. Both have a dioicous inflorescence.

Bryum demissum, or the *club-fruited thread-moss*, is not unlike *B. Zierii* in the form of its capsule, which is similarly oblique-mouthed, but its foliage, except in colour, resembles that of *B. cæspiticium*. It is also altogether of a more compact and dwarfish habit than *B. Zierii*, its stems scarcely reaching a quarter of an inch in height, bound together by the small radiculose fibres which cover them, and the short innovations and branches which they put forth. The capsule, too, has a shorter neck, a more oblique mouth, an inner peristome proportionally longer, with irregular segments variously united, and short, mostly solitary cilia. Its leaves are reddish, but in other respects too closely resembling our common species *B. cæspiticium* to require a separate description. It is very beautiful, and one of our rarer species, found only in the fissures of rocks in exposed situations; has been met with upon Craigalleach and other summits of the Breadalbane range, and fruits in August and September. Its inflorescence is dioicous.

Bryum cæspiticium, or the *lesser matted thread-moss*, is of very frequent occurrence, having no particular local predilections, but growing sometimes on the ground, and as often climbing walls and rocks, or seating itself upon the roofs of houses, where it grows in tufts more or less compact of a yellowish or intense green, the stems being from two lines to an inch in length, having innovations and also sterile branches, slender and attenuated, not much unlike those of *B. julaceum*. As in *B. Capillare* the terminal leaves are larger than the rest, but all of them are erect and straight when dry, therefore the two species can never be confounded. The capsule too is paler and smaller than that of *B. Capillare*, with a paler peristome, and a yellow not red lid, and also enclosing yellow, not green spores. Nor are the leaves so suddenly and roundly terminated; but while the nerve is more or less excurrent the laminar portion of the leaf more gradually tapers to it, being lanceolate acuminate at the point and ovate at the base, the margin recurved, and the apex either entire or serrulate. The inflorescence is dioicous, and the oblong-obovate or ovate capsule slightly constricted below the mouth when dry. There are several varieties of this moss, with slight differences. *B. cæspiticium* ripens its fruits in May and June, as does also the still more common species—

Bryum Capillare, or the *greater matted thread-moss*, the frequent ornament of our walls, rocks, trunks of trees, etc., where its beautiful little pendant capsules, of a reddish-brown colour, with red, shining, apiculate lids, are calculated to attract the eye even of the careless. It is one of our most common species, variable both in size and general aspect, seven varieties having been already enumerated; but it may be usually known by the obovate, abruptly narrow pointed leaves, which as in *B. torquescens*, to be described hereafter, are strongly contorted when dry. The lower leaves are ovate oblong and apiculate, but smaller than the upper ones, which become larger, obovate oblong, with long slender points, seeming to render the leaf almost piliferous, entire, or sometimes serrulate at the apex, the nerve either ceasing below it or occasionally excurrent; and the margin of the leaf reflexed, and frequently composed of narrower cellules than the rest, thus giving it a bordered appearance. The stems are radiculose below, sparingly branched either at the base or at the flowering summit, and measuring from a quarter of an inch to an inch in height. The capsule, too, is variable in shape, but usually oblong-pyriform, or sub-clavate in outline, and scarcely constricted below the mouth when dry. The outer teeth of the peristome are of a reddish brown tint, the inner more deeply coloured,

and less deeply divided than in *B. cæspiticium*. The spores are small and green, and the inflorescence is dioicous.

Of the different varieties of this moss variety *majus* grows more densely tufted, has a longer stem, broader leaves, surrounded by a broader and more evident border, an excurrent nerve, and a larger and thicker capsule.

Variety *minus* has a smaller capsule, concave imbricated leaves, and roundish sterile branches.

Variety *flaccidum* has slender branches, with more tender flaccid leaves of a pale hue, the lower ones purplish, not contorted when dry, and more evidently serrated at the apex. This is the *Bryum stellare* of Smith's *English Botany*.

Variety *Ferchelii* has slender stems and branches, very compactly tufted, smaller, leaves obovate-acuminate, concave, reddish, and sub-piliferous, with a smaller obovate, and at length truncate capsule, constricted below the mouth.

Variety *carinthiacum* has slender elongated stems, with slender branches, and erecto-patent leaves of a reddish hue, obovate, rather broad, shortly acuminate, obscurely bordered, and slightly twisted when dry.

Variety *cochlearifolium* has roundish branches, with very concave glossy leaves, roundish, and having narrowly reflexed points, the fruit-stalk thicker, and the capsule obovate-pyriform, and quite pendulous. This beautiful variety is called by Nees ab Esenbeck *Bryum elegans*.

The much rarer species, *Bryum Donianum*, or *Don's thread-moss*, is not unlike *B. Capillare* in aspect, but the leaves have only very short points formed by the scarcely excurrent nerve, and are by no means suddenly attenuated and subpiliferous as in that species. They are scarcely obovate, more resembling those of *B. pallens*, which has also what *B. Capillare* never has, a *thickened* border, though less conspicuously so than is seen in this species; and when dry the leaves are only crisped or undulated, and slightly twisted, not contorted as those of *B. Capillare*. They are also of a green colour, never reddish, and of a somewhat firmer consistence than found among its allies. The sub-pendulous capsule is of a pale reddish brown, long, clavate, with apiculate lid, and contracted below the mouth in the dry state. Its habitats are rocks and sandy banks. Winwick Stone Quarry, near Warrington, and near Conway, North Wales, are the localities in which Mr. Wilson mentions having found it—a damp sandbank near Hurstpierpoint; and also the neighbourhood of Winchelsea, in Sussex, are likewise mentioned as having been visited by its presence.

During the month of September and early in October, on the Clova mountains, at a considerable elevation, near the limits of perpetual snow, where Hooker says it was seen in

considerable plenty in 1824, on declivities by ravines, on Ben Lawers, Ben Nevis, and Carnedd Llewelyn, in North Wales, may be found *Bryum Ludwigii*, or *Ludwig's thread-moss*. Having a dioicous inflorescence, it is not commonly met with in fruit, but its bright green extensive patches are conspicuous even in the barren state. Its stems are about an inch or more in length, reddish above and blackish below, in colour akin to the light blackish soil in which its decumbent base is usually buried, having the lower faded leaves of a reddish tint, while the upper are of a full bright green colour, decurrent at the base, concave, rather obtuse at the apex, which is slightly serrated, and more or less spreading. The fruit-stalk, slender and flexuose, is about an inch long, reddish, and suddenly bent below the neck of the pendulous, somewhat pear-shaped, or oval-oblong, brownish capsule, which is slightly incurved, its neck tapering into the fruit-stalk, its conical lid more or less obture, possessing an annulus, becoming slightly constricted below the mouth when dry, and having the inner peristome furnished with cilia, two or three together. The barren flower is compactly gemmiform, and at first terminal, but subsequently, in consequence of the growth of terminations, it becomes lateral.

Bryum pseudotriquetrum, or the *Alpine bog thread-moss*, is another lover of the mountain heights, frequenting wet rocks and banks on the Scottish and Welsh mountains, where it grows in large patches of a deep green colour, inclining to purplish or blackish, with radiculose stems like those of *Bryum binum*, from which, however, it is distinguished by the dioicous inflorescence; the leaves also are more rigid, especially in the dry state, and the fruit is generally more elongated; it is also more robust, ranging from one to three inches in height. It ripens its fruit in July, and in all other respects the description of *B. binum* will suffice for this.

Akin to these two is *Bryum Mühlenbeckii*, *Mühlenbeck's thread-moss*, with fasciculate, radiculose, dichotomosely-branched stems, and deep red foliage. It is said to have been found on moist rocks in Devonshire, but is extremely rare if indigenous. It was first found by Mühlenbeck, whose name it bears, on wet rocks on Mount St. Gothard, in 1839, and differs from *B. alpinum* in the larger, wider, more loosely-reticulated leaves, which are also so concave and obtuse as to be almost cuculate at the apex, the margin being revolute, and the colour dull red, inclining to olive. The inflorescence is dioicous, and its fruiting season said to be September.

Bryum binum, or the *Lowland-bog thread-moss*, grows in marshy and boggy places, has a synoicous inflorescence, and fruits in June and July, its stems rising from half an inch to

two, and sometimes even three inches in length, and having a lurid green appearance at the summit, and usually matted together by twining purplish radicles, which are copiously produced among the leaves, giving a thick woolly aspect to the dry specimens, and somewhat of a woolly sensation to the touch. These stems are more or less branched, and the leaves are spreading, widely so, on the young shoots; the lower ones distant, the terminal crowded and more erect, slightly twisted and erect in the dry state; ovate-lanceolate in form, somewhat decurrent, entire or slightly serrated at the apex, and submarginate, the nerve varying in length, usually more or less excurrent, the lower ones blackish or reddish-brown, the upper of a greener hue. The reddish-brown fruit-stalk, like the stem, varying in length from one to three inches, and bearing the more or less oblong pyriform capsule, with its concave apiculate, glossy lid; the capsule of a pale brownish or yellowish-brown colour, constricted below the mouth when dry, and having a dehiscent annulus.

A variety of this species, termed *cuspidatum*, from its leaves having longer bristly points, grows in dryer situations, on walls, etc., and assumes so different an aspect, that, but for the difference of the inflorescence, it might be mistaken for *Bryum pallens*. Its leaves, as well as having longer bristly points, are of a more lively green, and the capsules are attached to shorter fruit-stalks. From *B. cæspiticium* it is distinguished by its pale roundish-pyriform capsules, and its synoicous inflorescence.

Bryum Marratii, Marrat's blunt-leaved thread-moss, has a monoicous inflorescence, and fruits in September, and specimens may still be obtained early in October. It was first found in 1854, by Mr. Marrat, of Liverpool, whose name it bears. The flat sandy shore at Southport, Lancashire, is named as its habitat. Its stems are gregarious, sparingly radiculose, about a quarter of an inch or more in length, bearing rather large leaves, of a light green colour and a soft pellucid texture, more or less spreading, concave, elliptical, obtuse, entire, and scarcely reflexed at the margin; those of the perichetium narrower, longer, and suberect. The capsule is roundish, at first of an olive colour and shining, but when ripe reddish-brown, with a small mouth covered by a rostellate lid, about one-third of the length of the capsule, a large annulus, and a neck tapering into the fruit-stalk, which is reddish, and about an inch long. The teeth of the outer peristome are trabeculate externally, of a deep red colour, connivent into a cone, and remain unaltered when dry; the inner peristome is imperfect and adherent to the outer, the spores are large and yellowish, and the inflorescence monoicous or often synoicous.

Wilson says:—"This very remarkable species was at first supposed to be an accidental form of *B. latifolium*, but it is now ascertained to be essentially different, though nearly allied;" and that it is readily distinguished from *B. latifolium*, a continental species, "by the small roundish capsule, rostellate lid, red peristome, and narrower obtuse leaves, with a shorter and thinner nerve."

The other members of this genus, which contains the most numerous examples of indigenous thread-mosses, fruit chiefly in the summer months, June, July, and August; but *Bryum Roseum*, the *Rosaceous thyme thread-moss*—which Wilson rightly places as the last of the Bryums, exceeding in size any other of the species indigenous to Europe, and forming a link between them and the *Muiums*—fruits in November and December. It is a large and very handsome species, the stems reaching from one to four inches in length, giving off branches below the surface of the soil, having the lower leaves very small and inconspicuous, appressed and somewhat decurrent; the upper ones large and widely spreading, slightly recurved, spathulate and apiculate, flattish, with the margin not thickened, but recurved in the lower part and serrated in the upper, the nerve usually ceasing below the recurved apex. The capsules are large, pendulous, oblong or sub-cylindrical, slightly curved, reddish-brown, with short necks which taper into the fruit-stalks, two or three of which are often aggregated together, varying from half an inch to two inches in length. The annulus is large, and is spirally dehiscent; the lid convex, with a short point, shining and reddish. It inhabits shady banks, chiefly in a sandy soil; but the inflorescence being dioicous, it is seldom met with in fructification.

Space will not allow of our noticing more than these at present, though some of the summer-fruiting Bryums are exceedingly lovely; but we trust that many of our readers will find pleasing employment for their microscopes in verifying the descriptions of those given, and in searching out the others in due season. Every eye is pleased with the soft verdure of these denizens of wood and wild, but only his who gazes on them through a powerful lens can duly appreciate, or even in the remotest manner apprehend, the latent beauty whose elements, thick set in every part, elude the most prying, unassisted vision.

AIDS TO MICROSCOPIC INQUIRY.

III.—Heat and Organization.

Life, as we know it in connection with organization, would be quite impossible without heat. If we start with the simplest form of plant or animal, we find that its life consists in an assemblage of actions, no one of which can be distinguished from the effects of *physical* force. As we ascend in the scale of being, the phenomena of sensation, consciousness, intelligence, and volition come gradually into view. We do not *see* them manifested, except in connection with organization, and we can prove that physical changes take place whenever a living creature experiences or performs a mental process of any kind. How, and why, mental phenomena are associated with the motions of physical particles we are profoundly ignorant, and our minds are so constituted that we cannot possibly regard any change in the position or arrangement of atoms or molecules as resembling in *kind* the changes which take place in our mental condition when sensations are felt, ideas are formed, or desires evoked. But however distinct mental operations may be from the physical movements of living beings, the latter must be regarded from a strictly physical point of view. If, for example, no man can think without a certain portion of brain substance passing into a new state, we must look to physics and chemistry to elucidate the transition, and if we cannot explain it by the laws pertaining to these sciences, we had better honestly and frankly confess our ignorance rather than try to mask it under such a term as *vital force*—a phrase by which no precise meaning is conveyed.

Now, if we separate from manifestations of life all those phenomena which belong to metaphysics, the mass that remain may be regarded as under the special dominion of heat. We do not say that they are only divers manifestations of heat, for this would be obviously incorrect. All forces may prove to be ultimately resolvable into *one force;* but if science ever reaches this point of development, it will still be convenient to give separate names to the distinct manifestations in which the ultimate force may be displayed.

Heat may be best considered, with Tyndall, as "a mode of motion," and temperature will be found to be an essential and dominant condition of living organisms, determining what other motions can take place. If we heat a bar of iron, we expand it, and at the same time augment its affinity for oxygen, so that if that gas be present, combination must ensue. When we come to considerations specially drawn from chemistry, we

shall trace this kind of action to a greater extent; but it may now be stated that a certain rate of composition and decomposition is essential to organic life, and that heat is one of the influences by which such actions are stimulated and controlled.

Temperature determines whether bodies shall be solid, fluid, or gaseous. Organic life, as we know it, demands the co-operation of matter in these three states, and, consequently, too much or too little heat is fatal to its existence.

When heat is applied to any substance, it acts in two ways. It effects a certain change in the arrangement and mutual distance of its particles, and it also warms it. That portion of the heat which is employed in changing the internal condition of the substance does not directly help to make it hot. When the fact was first discovered that the temperature of a body, as measured by a thermometer, or made manifest to our sensations, was not augmented in direct proportion to the quantity of heat communicated to it, the term *latent heat* was employed; but the new discoveries concerning the correlation of forces afford a better explanation, and we no longer regard the heat as *hidden*, but as having taken another form, or become another force. It can be shown, for example, that a certain quantity of heat is convertible into an equivalent quantity of mechanical force, and, on the other hand, that a certain quantity of mechanical force is convertible into an equivalent quantity of heat. Firing off a rifle is a good illustration of this matter. The heat arising from the combustion of the powder expands the solid materials of which it is composed into an enormously larger bulk of composite gases. By suddenly occupying more room, the powder expels the ball with great velocity, and the ball moves because heat has been converted into motion. On reaching the target, the ball stops, and both it and the target are heated. In this case motion has been converted into heat. In firing great guns at iron targets a flash like lightning appears at the moment when the motion of the projectile is arrested. If the earth's centrifugal motion ceased, it would fall into the sun, and the "amount of heat generated by the blow would be equal to that developed by the combustion of 5600 worlds of solid carbon."*

The temperature of a body is, as we have said, not an indication of the quantity of heat it has received. "To raise a pound of water, for example, 1°, would require thirty times the amount of heat necessary to raise a pound of mercury 1°. Conversely, the pound of water in falling through 1°, would yield up thirty times the amount of heat yielded up by the pound of mercury." The heat which is not engaged in producing *hotness*, if we may use the word, has been employed in in-

* Tyndall's *Heat as a Mode of Motion*, p. 43; *ibid*, p. 143.

ternal work, and is given back when the body cools, and its particles go back to their original state. Generally it happens that adding any quantity of heat to a body does something towards augmenting its bulk; but there are some curious exceptions to this rule. Fusible metal, for example, expands in cooling and solidifying, and if, after having thus expanded, it is remelted by heat, its bulk is again reduced. "Water expands on both sides of 4° C. or 39 F.; at 4° C. it has its maximum density. Suppose a pound of water heated from 3½° to 4½° C., that is, 1°, its volume at both temperatures is the same; there has been no forcing asunder whatever of the atomic centres, and still, though the volume is unchanged, an amount of heat has been imparted to the water, sufficient, if mechanically applied, to raise a weight of 1390 lbs. a foot high. The interior work done here by the heat can be nothing more than the turning round of the atoms of water. It separates the attracting poles of the atoms by a tangential movement, but leaves their centres at the same distance first and last."*

Very important consequences to life arise from the class of facts just mentioned.

If, for example, water did not consume a good deal of the heat communicated to it in internal work, it would under solar influence grow too hot for most of the creatures that now dwell in it. If a bowl of mercury and a bowl of water were both exposed to a broiling sun, the former would become unbearable, while the latter would only become tepid.

For the comfort of the world it is necessary that water should be able to keep comparatively cool, in spite of the summer heat of the tropics; but its constitution enables it to do more than avoid an excess of temperature. It takes in much more heat than is necessary to give it a proper degree of warmth, and when cold weather comes, or when a warm tropical current flows into cooler regions, it gives back to the air a quantity of its stored-up heat that is sufficient to make climates temperate that would otherwise be frigid and severe.

When an animal is exposed to a temperature much above that which its solids and fluids could reach without destruction, it escapes from getting too hot by setting the superfluous heat to do another sort of work. It may, for example, evaporate its fluids, and as they take a gaseous form, they absorb so much heat in the internal work of separating their particles that no mischievous augmentation of temperature can result.

Numerous illustrations of these actions might be given. One of the most interesting is afforded by Mr. Babbage, who thus recounts his visit to Chantrey, when the sculptor had heated a great oven for the purpose of drying the moulds of a

* Tyndall, p. 146.

large bronze statue. "The iron folding-doors of the small room or oven were opened. Captain Kater and myself entered. The further *corner* of the room, which was paved with square stones, was visibly of a dull red heat. The thermometer marked, if I recollect rightly, 265°. The pulse was quickened, and I ought to have counted but did not count the number of respirations per minute. Perspiration commenced immediately, and was very copious. We remained, I believe, about five or six minutes without any very great discomfort, and I experienced no subsequent inconvenience from the result of the experiment."*

Bodies may receive and part with heat in two distinct ways—by conduction and by radiation. If we hold our hands near the fire, or a hot iron, we are warmed by the heat that is radiated. If we touch a glowing coal or a hot iron, we are warmed or burnt by the heat that is conducted from the hot body to ourselves. Radiation takes place at any distance. Conduction requires contact. The nearer we are to the radiating body the more heat we receive, and if we recede from it, we lose the heating effect as the square of the distance is increased.

Water is a bad conductor of heat, the ordinary metals conduct it well, hair and fur conduct it badly, mica and such bodies still worse. A couple of inches of iron can be heated through very quickly, but a couple of inches of talc or mica keeps out the heat for a long time, and a box of metal with sides sufficiently thick to resist fusion, may be made fireproof by lining it with a couple of inches of a very badly conducting substance like those we have named.

Bodies differ in radiating power as well as in conducting power. A bright metal teapot radiates little and keeps warm, while a black earthenware one radiates much, and gets cool in the same time.

Heat may be reflected like light, and good reflecting surfaces will keep heat out, while good absorbing ones will take it in.

The escape of heat by radiation from the earth's surface, varies according to soil, climate, and state of the weather. In clear, dry air it goes on with rapidity, so that frost at night follows a sweltering heat by day, and no animal or vegetable can live in such countries, unless fitted to bear sudden and violent extremes. Moisture, or vapour in the air arrests the dispersion of heat by radiation, and hence climates that are temperate are never excessively dry. Even perfumes exert powerful effects. Most minute are the quantities of matter given off in the scent of flowers. "No chemist," as Prof.

* *Passages from the Life of a Philosopher*, p. 213.

Tyndall says, "ever weighed the perfume of a rose," but the perfume of the rose absorbs radiant heat with 30½ times the power of the air, and that of aniseed with 372 times the air power. "It would be idle," adds Prof. Tyndall, "to speculate on the quantities of matter implicated in these results. Probably they would have to be multiplied by millions to bring them up to the tension of ordinary air." Thus—

> "The sweet south,
> That breathes upon a bank of violets,
> Stealing and giving odour,"

owes its sweetness to an agent which, though almost infinitely attenuated, may be more potent as an interceptor of terrestrial radiation than the entire atmosphere from bank to sky.*

In the present state of investigation it is impossible to state the precise limits of heat and cold, beyond which all living organisms are destroyed. On Alpine snows the Protococcus, a simple confervoid plant, forms red patches, and grows in spite of the cold, while other members of the same family rejoice in warm situations. If we pass from low to high temperatures, we meet with some curious examples of vegetable life flourishing at a heat we might have fancied fatal to its existence. "In the hot springs near a river of Louisiana," for instance, "of the temperature of from 122° to 145°, there have been seen to grow, not merely Confervæ and other herbaceous plants, but shrubs and trees; and a hot spring in the Manilla islands, which raises the thermometer to 187°, has plants flourishing in it and on its borders. A species of Chara has been found growing and reproducing itself in one of the hot springs of Iceland, which boiled an egg in four minutes; various Confervæ, etc., have been observed in the boiling springs of Arabia and the Cape of Good Hope; and at the island of New Amsterdam there is a mud spring which, though hotter than boiling water, gives birth to a species of liverwort."†

Dry spores of Uredo, according to Hoffmann, are not killed by a heat of 128° C.; but the experiments of Julius Sachs on the highest temperature that vegetation can sustain, throw much doubt on the extreme statements of certain other observers. M. Sachs found that in the space of ten to twenty minutes, a temperature of 51° C. in the air, killed the most diverse kinds of plants, and 45° to 46° C. in water sufficed to cause death.‡ It does not however follow that because plants that had been growing at lower temperatures were killed by such an augmentation of heat as he describes, that similar plants

* Tyndall, p. 360.
† Carpenter's *Manual of Physiology*, p. 63, 3rd edit.
‡ *Flora*, Jan. and Feb. 1864; *Archives des Sciences*, July, 1864.

might not have germinated and grown above the temperature of his experiments.

From these facts it will appear that both high and low kinds of plants will stand what might be deemed an excess of temperature in the direction of heat; but few plants, except those of low organization, will survive extreme cold. Within the polar circle, the nearest approach to a tree is a minute willow, six inches high; but the short summer is gladdened with rushes, and a few flowers such as Potentilla, Ragged Robin, and Bachelors' Buttons. The greatest cold is sustained by Cryptogams, and the yeast plant will survive 76° below Zero.*

The animal world can resist great extremes of cold if supplied with suitable food. The fur of the Polar bear keeps in the heat which is generated by respiration and other functions of the body, in which a slow combustion occurs. In such cases the creature is warm, although the atmosphere he lives in is cold.

The effect of heat is to accelerate the processes of life, and if a cold-blooded animal, such as a frog or a serpent, is kept very warm, its activity is stimulated, and its life brought to a speedier close. Some creatures can stand a complete suspension of vital action without being killed. Thus in one of Captain Ross's voyages certain caterpillars were frozen, so that they chinked like ice when thrown into a tumbler, and resumed their activity when thawed. Even animals so high as certain fishes may be frozen so as to become quite brittle without life being destroyed, and the mud-fish of Africa may be dried to a chip without being killed. Warm-blooded animals are more limited in their powers of endurance, and an arrest of vitality that would not hurt a reptile, is usually fatal to them.

"The highest limit of temperature compatible with the life of fishes has not been certainly ascertained, and it appears probable that there are considerable variations in this respect amongst different species. Thus it is certain that there are some which are killed by immersion in water at 104°, while it is also certain that others can not only exist, but can find a congenial habitation in water of 113°, and even of 120°, and examples of the existence of fishes in thermal springs of a much higher temperature have been put on record. Various fresh water mollusks have been found in thermal springs, the heat of which is from 100° to 145°. Rotifers and other animalcules have been met with in water at 112°. Larvæ of tipulæ have been found in hot springs of 205°."† After this we cannot be surprised

* Carpenter's *Manual of Physiology*, p. 69.
† *Ibid*, p. 86.

when we are told that cooking does not always destroy entozoa inhabiting such a dainty as "measly pork."

The temperature that will kill all germs of infusorial life is not settled, and it has even been asserted that they are not all destroyed when air is made to pass through tubes filled with red-hot pumice or similar matter.

Heat increases the mobility of fluids, and hence their passage through small vessels and through the pores of delicate tissues is facilitated by warmth.

Heat assists the solution of most bodies, and plays an important part in chemical actions. These will form the subject of consideration another time, and they are only mentioned in this place to show they are not forgotten.

The boiling and freezing points of water are much affected by the presence of other substances in solution. Thus fresh water freezes at 32° F., while sea water freezes at about 28·5°. In like manner pure water boils at the sea level, and at the ordinary barometric pressure, at 212°; but if saturated with common salt the solution does not boil till it has reached 224°, and if Rochelle salt be substituted for common salt, not till 240°.

The boiling and freezing points of liquids are also regulated by pressure. The greater the pressure the greater being the resistance to any change of condition that demands mobility of particles, or enlargement of bulk. Thus "M. Mousson found that a powerful pressure not only retards the freezing of water, but prevents its complete solidification. In this case the pressure opposes the tendency of water to expand on freezing, and thus virtually lowers the point of solidification."*

With reference to *boiling*, the rule is that a liquid boils when its tension is equal to the pressure it supports. Now the pressure on a mountain top is considerably less than at its base, and a corresponding lowering of the boiling point is observed. On high mountains the direct heat of the sun received by a good absorbing surface, produces a very high temperature with a corresponding dilation of fluids or solids; but there is an abrupt and violent transition from the heat of direct sunshine to the cold experienced in the shade. This arises from the rarefaction and dryness of the air at great heights. Suppose, then, either plants or animals so situated, that as the sun moves on they are first intensely warm, and then suddenly and violently cooled as his beams are kept off by a wall of rock; to live under such conditions they must be of a hardy type.

It often happens that plants will stand a severe cold during the winter, or at night, provided they have enough heat during

* Ganot's *Physics*, by Atkinson, p. 228.

the day, thus "some palms flourish luxuriantly far inland, on the tops of mountains 14,000 feet high, and in the immediate neighbourhood of perpetual snow."*

Organic bodies of all kinds furnish subjects for microscopic investigation, and it is hoped that this brief sketch of some of the more important properties of heat will assist the beginner in his pursuit. It is very important to note the physical conditions under which organisms are developed and thrive, and if we can succeed in starting our friends in studies of this nature they will experience a two-fold pleasure from their investigations, and readily find in scientific treatises a larger body of information than we could attempt to give.

THE RHINOCEROS IN BHOTAN (*RHINOCEROS INDICUS*, Cuv.).

BY R. C. BEAVAN, LIEUT. BENGAL SURVEY.

Of all the large game in India the rhinoceros has gradually become the rarest, and has been driven by the progress of civilization further and further from the haunts of men, until now it is to be found only in the dense untrodden jungles which skirt the bases of the Eastern Himalayas, and the branches of that chain which penetrate Assam.

The range of the Indian rhinoceros formerly extended to the Ganges, and within the memory of man an occasional straggler has been seen in the dense vegetation which in places borders that mighty river; but their present stronghold, shared also by the wild elephant, is that belt of country called the Terai, which extends along the base of the Himalayas from Nepaul to the valley of the Burrampooter in Assam.

Unlike the African, the Indian rhinoceros has but one horn, which is seldom seen of more than 12 to 16 inches in length, and its body is well protected by a coat of mail, whilst its size in its native wilds far exceeds that of specimens seen in captivity.

Far remote from human habitations, it frequents during the day the densest reed covers, and passes the time either in sleep or in wallowing in the swamps, the tracks it leaves behind it being often as large as if elephants had been there. They generally live in families of four or five together, and are considered by those acquainted with their habits the most dangerous to attack of all Indian wild beasts. Leaving their

* Berthold Seemann's *Popular History of Palms*, p. 32.

coverts at nightfall, they issue into the surrounding savannahs, to crop the herbage, and have frequently been known to oust the herds of semi-tame buffaloes from their pastures, to the no small alarm of the half-wild herdsmen.

When provoked, the rage of the Indian rhinoceros is almost beyond conception; it charges blindly with great violence, and combining as it does enormous weight with an almost bullet-proof hide, its onset is much dreaded by even the staunchest in the line of elephants engaged in beating, and as often as not the majority turn tail and bolt in fine style. Many a good elephant will stand repeated charges from a furious tiger with unconcern, but proves itself to be an arrant coward when opposed to an Indian rhinoceros.

This animal must not be confounded with other species* of the same family, also called *Indian* rhinoceroses, which frequent the forests of Burmah and the Malayan peninsula, but which in size or strength are far inferior to it.

Bhotan, one of the localities in which it is found, is a large independent state on the north-east frontier of Bengal, most of it a *terra incognita* to Europeans, owing to the strictly exclusive Indo-Chinese policy exercised by its rulers.

The author was for some months stationed at the little out of the way village of Julpigorie, an outpost on this frontier, and situated on the banks of the river Teesta, which, after leaving the Sikkim Himalaya, forms the boundary between the British district of Rungpore, and the country of the Bhotanese.

By gentle means, *i. e.*, occasional requests, invariably accompanied by sundry bottles of rum or other spirit, the Soubah or head man of the district immediately opposite the station was frequently wheedled into granting permission to a few officers of the native regiment stationed there to cross the frontier into his territory for a day's shooting; but as the leave thus obtained expired at nightfall, it being contrary to the laws of the land for an Englishman to pass the night in their domain, the distance one could penetrate into the interior was necessarily limited to twenty or thirty miles. Within this radius, however, during the hot weather, when water was scarce, plenty of game was to be found, and the officers of the —th Bengal Native Infantry were not slow to avail themselves of these advantages.

Three of us started one fine morning in May, the hottest month in these parts, with eight elephants as beaters, making, with those that carried us, eleven in all. We had to proceed a few miles up the river Teesta before it could be forded, for

* *Rh. Sondaicus* (S. Muller) of the Indo-Chinese region, and *Rh. Sumatranus* (F. Cuv.) of Burmah.

though in many places apparently shallow, the quicksands which frequently occur rendered this preliminary operation dangerous in the extreme for elephants. At last fairly across, we enter a dry, grassy-looking country, with occasional patches of cultivation, and here and there a few huts are clustered together under the shadow of a clump of bamboos or plantains.

In the background, especially after rain, are seen the clear outlines of the Himalaya Mountains: many of the peaks tipped with snow contrast strongly against the dark masses of the lower ranges, and produce a very fine effect. The lowest range from Julpigorie is only forty or fifty miles distant.

Moving onwards, we occasionally come across a high bamboo fort belonging to the Bhotanese, who, by nature mountaineers, are kept in small parties, scattered over this *plain* portion of their country, to hold in check their Bengalee slaves, who are inured to the heat, and till the land for their masters. This flat portion of Bhotan grows nearly all the rice and corn produce for the mountainous district, and is in fact the richest part of the whole kingdom. Were the British to occupy this, as they did in the case of its neighbour Sikkim, it would inflict a heavy blow on this turbulent nation, who are always quarrelling, either amongst themselves or with their neighbours, and have on various occasions laid themselves open by indiscriminate slave-stealing, to war with the British Government.

But "to return to our muttons." The belt of cultivation near the river is soon passed, and we come to a stunted tree jungle, chiefly sâlwood (*Shorea robusta*), the best timbers of which have long been cut up, and floated down the river to Calcutta for railway sleepers. This wood is considered the best for that purpose, being so hard that it is the only one capable of standing for any length of time the ravages of the white ant; and cutting it up forms the principal occupation of a tribe of woodcutters, who eke out a miserable existence in this district during the rainy season, which floods the river, floats their timbers, and makes this tract of country the very hot-bed of fever and malaria.

After leaving the sâl forests, we reach a vast plain, covered with large patches of high reeds alternating with grass savannahs. The tallest and greenest of the reeds indicate the existence of some half-dried-up pool of water, and in beating up several of these patches, we put up plenty of, to us, *small* game, which is allowed to pass unmolested, though to a "griff" the temptation to fire into a sounder of hog, or at a perverse hog deer (*Hyelaphus porcinus*), which gets up just in front of the elephant, can scarcely be controlled.

Many a fine florikan (*Otis houbara*, bustard), partridge,* or peafowl, rises within tempting shot,† deer of different species, pigs, and hares, are seen at every step; but unless a tiger turns up, to waste powder on anything smaller, at the risk of alarming the rhinoceros, which are known to be in the vicinity, is strictly forbidden.

At length, when in the middle of a thicker jungle than usual, a terrific crashing is heard, accompanied with an occasional loud expression of anger, half snort, half grunt, and the line of elephants show symptoms of wavering, which quickly resolve into a general pell-mell flight, as two enormous rhinoceroses are seen to charge down on the line. The howdah elephants alone are, by dint of repeated and energetic applications of the goad, kept by their mahouts from turning, but shake to that extent that clinging to the sides of the howdah is as much as one can do to prevent one's-self from being shot clean out. The idea of firing is out of the question until the animal gets steadier, when an ineffectual volley of heavy steel-tipped four-ounce conical projectiles is hurled at the game, but only has the effect of increasing their anger, for the largest of them having by this time overtaken one of the retreating elephants, wounds it severely in the flank, by a thrust with its horn. After breaking the line the rhinoceroses leave their cover, and debouch into the plain, which they cross at a pace which leaves the chance of overtaking them at once out of the question, and soon disappear in a low reedy ravine about half a mile distant. Though apparently an unwieldy animal, the rhinoceros at the top of its speed would require a good horse to beat it in a short distance. We proceeded to follow them up leisurely, to give time for the elephants to be reorganized, for three of them on first taking to flight had bolted some distance before their mahouts could turn them. When at last we reached the ravine, which by its numerous wallowing pits was evidently a favourite resort of the game, we proceeded to beat it with the greatest care, but had not gone far before a cry of alarm from the middle of the line caused a general inquiry as to what it was. On nearing the spot a curious spectacle presented itself, one of the elephants had inadvertently stepped into a quagmire, and immediately began to sink, and in a few minutes no portion of its huge carcase remained visible, excepting the head, trunk, and upper part of the back. We immediately proceeded to hew down the branches from the trees in the neighbourhood

* *Francolinus vulgaris*, St., black partridge, and *Perdix gularis*, Tem., Khaier partridge.

† 1. *Axis maculatus*, Gray, spotted deer; 2. *A. porcinus*, hog deer; 3. *Rucervus Duvancelii*, Cuv, the barasingha; 4. *Rusa Aristotelis*, the sambur; 5. Black buck antelope (rare).

to throw to the beast, and we gave it also the straw-stuffed pad off its own back, which materials it placed under its body, and after some time raised itself up sufficiently to allow the other elephants to help it out with ropes. After this delay, as the day was far spent, we determined to beat back homewards, and by great good luck, in a small patch of reeds near a swamp, came across a herd of from seven to eight rhinoceroses. R., who happened to be near them when they broke cover, fired right and left, and to our intense astonishment, down dropped two of the huge beasts. Had we not seen it ourselves, it would have appeared a veritable Munchausen's tale, for it is a well-known fact that one of these animals will frequently carry off ten or twenty heavy bullets in its body without ceremony.

In the whole course of the experience of our veteran leader, Colonel M., such a thing had before never been done; but here was the fact, in both the animals the bullets had pierced the vertebræ of the neck, and R.'s feat was, as may well be supposed, the theme for conversation for many a day after.

As it was now dusk, we had to leave the spoil where it fell, but sent a couple of elephants and a few natives with axes next day to bring in the trophies, their heads, horns, and armour-plates, and part of the flesh, which some experimented on, cooked like a steak, but, though eatable, it was found uncommonly tough.

The hide of the animal is made by the Bhotanese into small round shields with brass bosses let in, and are considered by them to be bullet-proof. We reached home well shaken and tired about ten p.m., but thoroughly satisfied with the day's sport.

IRISH VOLCANOES.

BY PROFESSOR D. T. ANSTED, F.R.S.

THE title of this article will most probably suggest to the reader a disquisition, more or less political, concerning certain familiar but very troublesome questions that arise from time to time both in and out of Parliament, and of which religion, education, tenant-right, etc., are the catch words. Each of these subjects is indeed in Ireland a smouldering fire, liable to break out at any time, and, after disturbing the tranquillity of a district by moral earthquakes, may burst into flames that are mischievous, in proportion as they spread more or less widely. But it is not the history of such fires that we propose to discuss. There are in the green island of Erin certain visible and tangible remains of volcanoes, such as exist in Iceland and

Sicily; or, at least, there are results of similar volcanic disturbances to those which take place at the bottom of the sea near Hecla and Vesuvius, and these are by no means small or unimportant. A tolerably extensive district in the north of Ireland is covered with lava once poured out in a fluid state from yawning crevices in the solid earth. Grand and lofty cliffs owe their grandeur and elevation to the protection afforded by this late, though not last, event in the physical history of the country, and one of the most striking and best known of the picturesque phenomena of Ireland—the GIANT'S CAUSEWAY—is nothing more than a very small fragment of this floor of old volcanic workmanship exhibited under peculiar conditions, and invested with a legendary interest professing to date back to the heroic period when great men were giants, and when giants were supposed able to conquer nature, and perform miracles of strength and intelligence.

The tourist crossing from Fleetwood or Morecambe to Belfast, and travelling northward or westward by road or rail; and the navigator sailing round Fairhead on his way into the open Atlantic, are generally little aware that they are crossing a floor of lava as clearly marked and as characteristic as any that have been poured out from the sides of a volcano during the present century. And yet nothing can be more certain; and there are many places along the coast and in the interior where successive beds of old lava may be seen resting upon the ancient sea bottom of chalk, and where we may study with perfect convenience the effect of the presence of molten rock on a material once identical with the soft chalk of the south-east of England.

And the scenery of this district is not less picturesque than it is interesting and instructive. Except the corresponding but smaller scenery in the Isle of Skye, on the opposite coast of Scotland, there is nothing at all like it in the British Islands.

There is indeed no example of columnar basalt so well adapted to show the history of the formation in any part of Europe; for though in the volcanic districts similar deposits may be made from time to time, they are not visible, since they can only be perfected under a considerable depth of water, producing slow cooling under great pressure. The baths of Bertrich in the Eifel, and some localities on the Rhine near Bonn, are the nearest similar examples.

To see only the Giant's Causeway, then, is to obtain but a very imperfect notion of the whole of the phenomena. The few acres there exhibited are but a minute fraction of the four or five hundred square miles of lava poured out and spread in thin layers over the chalk of the north-eastern counties of Ireland.

The single bed that is seen at the Causeway is but one of some five and twenty distinct eruptions, and of all these abundant evidence exists on the line of cliff between Londonderry and Belfast.

But the Giant's Causeway, if only a small part of the whole, is wonderfully perfect and characteristic, and affords the key to the whole formation. It is a natural tesselated pavement, extending from the foot of the cliff towards the sea below low-water mark; but it is confined to this one particular locality on the coast, and though it extends out seaward till lost under the waves, it does not seem to recur in the same state in any other place.

It is a pavement of which the pattern is so elegant and so perfect, that no one can wonder at the Irish superstition to which its name is due. No one would easily recognize, without some familiarity with such phenomena elsewhere, the connection between this marvellously regular pavement and the volcanic eruption to which it is unquestionably due.

The entrance to Belfast Lough from the sea is extremely picturesque. Hills rise on either side, some of them flat-topped and basaltic, others crowned with heaps of sand and gravel. To the north, these hills are backed by others of older rock and less formal appearance. On both sides and all round they are deeply tinged with the emerald green so characteristic of Ireland, and so striking to the eye of the traveller, even when he has only crossed from Lancashire to Ulster. The richness of vegetation does not, however, conceal the peculiar angular and almost grotesque outline of the principal hill on the north side, whose top is said to present a contour likeness to the nose and chin of the first Napoleon. The resemblance is not very striking.

Belfast itself is well worth a visit. The town is large, but it will not long detain the visitor who is bound for the Irish volcanoes. One of the Ulster lines of railway runs westward as far as Portadown, where it connects with the line to Dublin. It then proceeds north-westward to Londonderry, always over or near the old floor of lava. Another line runs first eastward, branching to Carrickfergus and Larne, and then westward, branching again to Lough Neagh. A branch runs northward to Coleraine and Portrush—and it is this which brings one most rapidly to the Giant's Causeway. It passes near Lough Neagh, the great lake of Ireland, and one of the largest in Europe, but not within sight of it. It passes over the fiery stream also, but that is for the most part hidden from the general traveller, though a geological eye would discover the fact here and there. The road from Belfast to Portrush is not remarkably picturesque, and offers nothing of special interest.

All the phenomena of the district are best seen on and near the coast; and the two or three hours taken up by the railway transit, are not more than a fit introduction to them. From the very nature of the case the rock poured out from the volcanoes is flat, and covers all varieties of surfaces pretty equally. Here and there there are gaps, and occasionally hills of sand, clay, and large or small boulders, cover the flat surface, preventing monotony.

The interesting points of the district are three—the great lake, the Causeway, and the coast road to Larne from the Causeway, passing Fairhead.

Lough Neagh is a singular rectangular piece of water, nearly sixty miles in circumference. The ordinary level of its surface is about forty feet above the sea, and much of the lake is of very moderate depth; so that if there were free communication with the ocean, it would soon be greatly reduced. It receives the waters of eight small streams, while only a single river runs out from it towards the north, reaching the sea at Coleraine. This river, the Lower Bann, passes through a second but much smaller pool (Lough Beg) immediately after leaving Lough Neagh, and in it there is a natural obstruction that prevents the drainage of the lake. By clearing away the rocks in the course of the Lower Bann, the stream has been quickened and the lake lowered, but a band of basaltic rock in Lough Beg effectually prevents any further reduction.

More than a century ago, a certain Mr. Richard Barton published a series of lectures on the subject of this lake. At that time, also (1751), several memoirs were written concerning it for the benefit of the Royal Society, and several maps of the lake were published. From these it would seem that there were once many more islands than now exist, from which it is probable that a large decrease of depth has taken place, those islands which were near the shore being now parts of the main land, and the area of the lake diminished.

The peculiar natural productions of Lough Neagh in the mineral kingdom are fossil wood and a number of so-called *gems*. These are not quite undeserving of the name, and the celebrated Boyle, in his treatise on gems, remarks, "there is a lake in the north of Ireland which supports fish as well as other lakes, where, nevertheless, in the bottom of it are rocks to which adhere masses of beautiful figured substances, in clearness and transparency imitating crystal." Innumerable specimens of chalcedony, agate, jasper, and common opal are found among the pebbles of the shores of the lake. The fragments of fossil wood are very numerous, and are sometimes so large as to weigh one or two hundredweight; the largest specimen recorded seems, indeed, to have weighed about seven

hundredweight. All are fragments of ancient trees converted into flint.

The waters of the lake have also been celebrated for their curative properties, and it has even been imagined that the name *Neagh* is a modification of the Irish word *Neasgh*, an ulcer. In the reign of Charles II. it is recorded that the son of a certain Mr. Cunningham, who had been touched by the King in vain for the "King's evil," was induced to bathe in this lake for eight days, after which his sores were dried up, and he was ever after a healthy man. Mangy dogs, no less than human beings, are said to be cured in this water.

The gems of the lake are found chiefly on the south-eastern shore; they are all, without exception, varieties of quartz minerals, and as they agree exactly with those got from the veins and crevices of the ancient lava of the Causeway, and do not agree with other forms of the same mineral within the British Islands, except under somewhat similar conditions, we may fairly conclude that they have been washed out of similar rock.

Of this the geologist, at any rate, will have no doubt, since, at a short distance from the lake, in a deserted quarry not far from Portadown, the basalt may be seen in contact with the chalk, which it there overlies, while, near the banks of the lake there are rotten veins in the basalt full of crystals.

That the general floor of the whole country around and to the east of Lough Neagh, is of the nature of ancient and generally submarine lava, is best seen on the coast, but it is capable of proof in abundant instances elsewhere. The soil itself, and the road-metal or broken stones used to make and mend the highways, has the same origin. The material is too good, and wears too well for the latter purpose, to admit of the smallest doubt as to its nature.

The well-known gems of Lough Neagh, then, must be regarded as the former contents of blebs and cavities in the old lava, or of the interspaces and cracks produced in the natural contraction of the mass while cooling.

Lough Neagh, as seen from the grounds of Brownlow House, the residence of Lord Lurgan, is extremely picturesque. The lake is at some little distance, and the long headland of Ardmore breaks its somewhat monotonous line, while the Tyrone Hills form a fine background; but generally, and from the lower ground near the water, the scenery is tame and uninteresting. Rocky and precipitous cliffs do not exist around or near it, and the general rarity of timber in the north of Ireland is fully experienced here. Extensive peat-bogs are found on and near the shores, and though these are rather interesting, owing to the large quantity of black bog-oak and

bog-pine they contain, nothing can render them in any sense picturesque. A considerable tract of nearly level ground has been recently gained from the lake, and this, no doubt, takes yet more from its beauty. There are not known in Lough Neagh any remains of those singular lake habitations so common in other parts of Ireland, but some of them are believed to have been constructed on Lough Beg, where the islands are more numerous, and the facilities for such dwellings were perhaps greater. Remains of that curious extinct deer, called the Irish elk, have been found in the neighbourhood.

The Giant's Causeway is some distance from Lough Neagh, but the basaltic or lava floor is continuous from the lake to the sea. At Portrush we come upon the coast, and though the village is not much above the sea level, the cliffs rise behind it, and on each side to some elevation, and very boldly. A short distance out at sea are several rocky islets known as the Skerries; these also are capped with basalt. Everywhere there is the same curious phenomenon—a white rocky base of the cliff covered more or less thickly by a gloomy black pall. Here and there only, a few hills of sand and boulders conceal this covering. On the shore, at the bottom of these cliffs, is a singular mixture of dead black and brilliant white pebbles, covered occasionally with fine sand. The structure of the cliffs, the variety of form of the detached and semi-detached blocks, and the numerous examples of pierced rocks, caverns, and broken, jagged, precipitous masses, is extremely striking; and the whole drive from Portrush to the Causeway, a distance of about eight miles, forms a fit introduction to the wonders of the locality. Dunluce Castle, a mediæval structure, now in ruins, is about half way; it is almost detached, and stands out boldly from the main line of the cliff.

What strikes the observer chiefly at this point is the fact that the white limestone below is separated from the dark rock above by a well-marked line, but that fragments of the white rock appear occasionally in the overlying black mass; while the black, or basaltic rock, often contains a considerable quantity of chalk, mixed up with and forming part of it. The white limestone, though hard, compact, and splintery, besides having a pinkish colour, is beyond all doubt the geological equivalent of the chalk of the north and south downs of England. The same admixture of flints, and, above all, the same curious and varied fossil species, are found in both; but the flints are altered as much as the chalk. Instead of being black, they are more generally red, and indeed are often converted into pure jasper. They are also cracked as if by burning, and look as if they had been re-cemented. Close to the junction of the two rocks, the white and the black, there are bands of red ochre, and a

sort of coarse paste of chalk, flint, and black rock. Very marked results are thus observable, identical with those produced by the action of heat, as exemplified in volcanic districts.

As we advance towards the Causeway, but some distance before reaching it, there is an enlarged crack in the chalk or limestone entirely filled by the black rock. The lava seems to have poured through this and other similar crevices, and, overflowing at the top, has spread out in a wide flat sheet; but not only this, large quantities of volcanic ash or scoria have also been erupted, and these have formed an intimate union with the mud of the sea bottom. Thus the lava alternates with this sort of strange paste, in which fragments of chalk and flint have been formed into a pudding, with a natural hydraulic cement or puzzuolana, and this confused mass contains also fragments of hardened lava and of flint.

In all these cases the black appearance of the basalt contrasts strongly with the chalk. At the distance of miles one can see the dividing line between the two formations, and as, on the whole, the water acts pretty uniformly on the chalk, while, in the case of the basalt, some parts are excessively hard, others quite rotten, and others again of intermediate condition as to durability, an extremely varied, broken, and irregular coast is the result.

The constant beating of the sea against the line of cliff from Portrush to Dunluce, has worn the chalk into forms of great variety and beauty—pinnacles, arches, and caverns succeeding rapidly one another, and the effect is much assisted by the striking contrast of the pure white colour of the chalk with the deep velvety black of the basalt. In some places arches are seen above arches, indicating a change of level or some peculiar local cause of decay. Very remarkable among these are the white rocks of Dunluce, marvellously picturesque, and offering much material for geological speculation.

The small but very neat town of Bush Mills, with its little stream in which thousands of fine salmon are annually caught, lies a little inland from the coast, and the road from Portrush to the Causeway winds round to pass through it.

Over a naked and uninteresting bit of road we make our way from Bush Mills to the Causeway Hotel, a comfortable house of entertainment, yielding all that can be expected in such a locality. Close to the hotel there is a convenient path down a steep cliff to a little bay, from the centre of which the long low Causeway stretches out towards the land of Staffa, where, though at the distance of many miles, a curious repetition of the phenomena exists. It is easy enough to see that it has taken many successive sheets of lava to build up this cliff. The whole from top to bottom is composed

of successive belts, consisting of lava perfectly loose and rotten, of other lava singularly compact and durable, and of rotten and altered vegetable matter or lignite, forming a kind of coal capable of being used as fuel, but of very pure quality. There are also beds of excellent and brilliant red ochre, and masses and layers of lava full of a beautiful white semi-transparent crystal. In the interstices of the harder rock, chiefly in the upper part of the cliff, are found numerous beautiful specimens of agate, chalcedony, and common opal, and occasionally jasper. All these are identical with the stones of Lough Neagh. At and near the foot commence those marvellously regular columns that characterize the Causeway. A little to the left, in descending (to the west of the Causeway), are the caverns. Beyond, on each side, the white rocks peep out from under the basalt. It is only on the east side, or between the Causeway and the noble promontory of Fairhead, that the basalt is strictly and regularly columnar, and indeed only a few cases occur within these narrow limits.

Most people when they first come upon the view of the Causeway, of which they have probably both heard and read, are a little disappointed at the smallness of the phenomenon. The portion of the shore so called is only about three acres in extent, and, contrasted with the extent of the coast line and the space of sea visible, this is certainly not much. The greatest length from the cliff to the low-water mark is about 220 yards, and the breadth is less than 120 yards. Within these narrow limits, however, there is so strange and remarkable a regularity in the rocks, they are so closely like artificial work on a large scale, they exhibit such elegant forms and proportions, and the result is so peculiar, and involves so great an apparent repetition of like parts, that any one accustomed to regard variety in detail as almost a law of nature, especially in rocks and stones on a large scale, is unwilling to accept the result. But everything resembling disappointment soon dies away, and is succeeded by wonder, and a strong desire to inquire into the probable cause of the phenomena.

The visitor is at once made aware of the difference between *columnar basalt*, and the comparatively irregular and shapeless masses technically called *amorphous basalt*. The latter abounds everywhere, and is what we have been already describing as spread over the whole district. It is intersected by scores of miles of coast. Along the whole line of coast, however, and over the whole area, the columnar development is rare and exceptional. The Causeway itself—those columns in the little bay adjoining, called the Organ, about midway up the cliff, and the two rows of columns called the Plaskets, forming parts of a much more lofty cliff about two

miles to the east—and the cliff near and at Fairhead, are all that can be referred to on the Antrim coast. Similar conditions of basalt are repeated in the Scotch island of Staffa, and the travelled reader may recal with pleasure the picturesque banks of the Rhine near Linz, and the cheese-ring grotto at Bertrich in the Eifel, as somewhat of the same nature.

The columns of the Causeway and the neighbouring cliffs are of two kinds; some are continuous for several feet, but they are usually made up of short fragments with an imperfect ball and socket connection, the rounded end of one portion fitting into the hollowed end of the piece next below. The continuous columns are generally smaller than the others, and their sides are often, though not always, less perfect.

The Causeway consists of a group of columns of the larger and more perfect kind, well divided into segments. The upper segments have all been removed close to the sea level, leaving only a kind of floor, almost horizontal. No doubt the columnar portion extends both far out to sea and far back into the cliff. Indeed there is little doubt that the former, now hidden by water, was the Causeway itself before the cliff was worn back to its present position, and the latter, hidden by the cliff, may be so hereafter when the sea shall have eaten away more of the cliff and laid bare fresh columns. It is quite certain that there is no permanence in the existing line of coast. Every winter fragments of the cliff fall, and during the spring these fragments are removed. In this change the whole floor partakes, and though the general appearance is not much, if at all affected, the details are inevitably subject to alteration. Thus no one need fear that the Causeway will disappear either by the frequent robbery of its most beautiful columns, or by a gradual wearing away. It is true that such destruction is inevitable, since the tide dashes over the floor of rock daily, and occasional storms sweep away all obstacles to the progress of the waves; but the results obtained to-day are but simple repetitions of those of yesterday, for they are due to similar causes which are still in action and will not soon change. The Causeway is, in fact, as fresh and as often renewed as the green grass of the fields.

A continuous walk over a few hundred yards of the Causeway reveals some curious facts. Every here and there is seen a beautifully perfect six-sided column, or rather the top of such a column, encircled by a row of six less perfect but tolerably regular columns, while this circlet is again surrounded by others gradually less perfect, as they recede from the centre. At a short distance, however, the outer circle of stones seems inexplicably to melt into the outer circle of another series, so that in walking alone one soon comes upon a second nucleus

precisely like the first, and not to be distinguished from it. This is repeated so often as to indicate a system. The result is recognized by the guides, who describe such centres as the "Lovers' Chair," the "Giants' Chair," etc. The whole area of tops of columns may be grouped in imagination into a number of circles, neither intersecting nor squeezing each other, but simply passing into each other almost insensibly.

If we take a particular column, selecting of course a good and fair example, it is easy to see that it is broken up by joints into frustra, each of which has one end convex or rounded, and the other concave or hollow. Two adjacent surfaces generally correspond, the rounded part of one fitting the hollow surface of the other. This is easily seen, for numerous little pools of fresh or salt water collect in the depressed or hollowed part of the stones when that part is uppermost.

While the columns remain in their natural condition, the upper and lower surfaces fit closely; but when exposed to the weather, a little moisture enters and discolours the rock. This causes decomposition, and towards the cliff, where vegetation can take root, it is curious to observe a matted mass of roots penetrating far within the apparently solid stone to a depth of some yards below the surface.

The appearance of the Causeway is that of a tesselated pavement somewhat irregular as to level, but of which the tesseræ or paving stones are extremely irregular. A careless observer might suppose that all were of the same size, and all the sides equal, both in number and length. It is only necessary to observe a little more closely to discover that this apparent uniformity is really made up of very discordant parts. Most of the stones are either five, six, or seven-sided, and it is easy to see that the six-sided figure is that which rules all the others. The perfect form of the section of the column is, beyond doubt, a hexagon or six-sided figure, all the six sides being of equal length. It is the section exhibited by a slice of honey-comb, placed upright so as not to lose any of the honey. But no two columns of the Causeway are exactly alike, and modifications occur in the actual dimensions of the columns and in the difference of length of the sides. Although, however, this difference might be expected to yield a result altogether indefinite, there are, in fact, very well-marked limits to the irregularity. Four-sided figures are very rare indeed, eight-sided figures almost equally so; and hardly a column of the 40,000 of which the Causeway is believed to consist has more than eight or less than four sides. The angles are generally very sharp. In point of dimensions, also, the columns are marvellously regular, hardly any being more than two feet in

diameter, and few of them less than 15 inches. The separate parts or joints of the columns vary in length from a few inches to as much as four feet.

There is generally a bold sea off the north coast of Ireland, and when the wind comes from a northerly quarter, especially from north-west, it is not a pleasant place from whence to start on a boating excursion. But as it is quite impossible to see and do justice to the peculiar and grand scenery of the coast two or three miles east of the Causeway without viewing it from the sea, those who are bad sailors must either make up their minds to considerable discomfort or wait for a very calm day. There is little danger, however, as the boats are built for the work, and the boatmen very experienced. It is an expedition worthy of any trouble. Lofty and vertical cliffs with two ranges of columnar basalt overlying, and separated by rough, irregular, and gloomy masses of similar rock, appear in a succession of small bays, the cliff gradually rising, and the position of the columnar part of the rock rising also till we reach the part called the *Pleskin*. Here the columnar rocks attain an elevation of nearly 400 feet, and are extremely bold, appearing even to overhang.

A peculiar feature of the cliffs near the Causeway is the occurrence at frequent intervals of wide spaces in the rock, filled with a variety of the common basaltic rock. These are locally called *whin-dykes*, a name certainly given by some geological visitor, but now familiar in the neighbourhood. These appear to be, and probably are, for the most part, mere clefts and crevices caused by the contraction of the original lava-bed while cooling, and afterwards filled up by other lava currents of later date. They are sometimes softer and more easily acted on by weather than the adjacent rock, and then they form narrow inlets. Elsewhere they are harder and less affected by the sea or the rain, and then they stand out as prominent buttresses. Detached pinnacles, caverns, and pierced rocks are among the common results of this difference of hardness in the cliff.

It is not difficult to make out the strata that together compose the whole thickness of the cliff between the Causeway and the Pleskin. They are from sixteen to twenty in number, and some of them contain fossils.

Beyond the Pleskin, as far as Fairhead, the cliff sections, though varying in heights and in some matters of detail, are, on the whole, of the same nature as those at the Causeway. In many places the chalk, hardened into limestone, stretch out as a white floor level with the sea.

At one well-known spot, named Carrick-a-Rede, a wild, rough, irregular rock, altogether detached, and otherwise

almost inaccessible, is reached by a narrow and fearful bridge, consisting of two planks fastened on ropes stretched across from the mainland to the rocky islet. The ropes are, of course, parallel, and are drawn as tight as possible, but the frail structure swings with every breath of wind. There is nothing absolutely dangerous in this bridge to one accustomed to walk on a plank, and not afraid of the temptation to throw himself over a precipice; but as it is not every one who is able to look down upon the roaring waves at a depth of 75 feet while being swayed backwards and forwards by the wind, it is probable that few visitors will be tempted to cross this bridge for the sake of having to come back again. The length of the bridge is about 20 yards. The fishermen of the neighbourhood set their lobster pots at the foot of the isolated rock, and dry their nets on its sides. They at least have no fear of accident.

Besides the fringe of small rocks, close to the shore, there are larger islands a little way out at sea. One of these, Rathlin, is of considerable size, and exhibits the same arrangement of white cliffs topped with black basalt that has been described as characteristic of the coast of the mainland. The basalt, however, is not columnar.

Ballycastle is a pretty and well-placed village, close to the sea, not far from Fairhead. It lies in a little recess, and the promontory of Benmore or Fairhead, the north-easterly extremity of Ireland, juts out very boldly as the continuation of a line of hill, mountain, and moor. Iron and coal have both been worked in the neighbourhood, and the ores of the former metal are still found in abundance, but the fuel is bad in quality and small in quantity. The higher hills, or mountains of this part of the coast, rise above the extreme point to which the basalt reaches, and thus form a picturesque break in the landscape.

The whole coastline from Fairhead southwards is grand and picturesque, though, perhaps, somewhat overrated in the accounts given by guide-books, and in picturesque descriptions of Irish scenery. From near Fairhead, where the road leaves the coast and crosses the moors to Cushendun Bay, there are fine views obtained of the Scotch coast, including the Mull of Cantyre and the conical island of Islay. In other respects there is nothing worthy of special note, except the fact that the high ground over which one passes is no longer basalt, but some old slaty rock, round which, as an island, the ancient lava has probably flowed. The higher parts of these old islands are now from 1500 to 1800 feet above the sea, but long since the lava flowed they have been partially under the sea, and have received a thick coating of sea-sand and gravel on their flanks. This is seen in many detached hills.

The old road formerly entered the Cushendun valley above the little village, and crossed a narrow ravine by a fine viaduct. A pleasing drive brings us to Cushendall, a curious and characteristic Irish country town, with many picturesque houses, and, altogether, in very good condition. High cliffs, almost perpendicular, rise immediately at the back of the houses of the town, and they are richly covered with vegetation. Just beyond the houses, at a turn of the road, there are caverns and arches in the sandstone rock of these cliffs, and habitations have been scooped out of the hill side. It is curious to see curling wreaths of smoke gently emerging from some unseen chimney, perforated through the hill, and one fancies that the real volcano itself has been found, from which all the lava has been poured out. Nothing can be less near the truth. These smoking sandstones are quite unaffected by anything that has happened to produce the phenomena of the neighbourhood.

All round the little bay, beyond Cushendall, as far as the river and pretty glen on its south side, the rocks are of this same sandstone, and from its brick-red colour the bay receives its name, Red Bay. Beyond the glen the old character of scenery recurs, thick beds of black basaltic rock above, and brilliant white limestone, hardened chalk, below. The road from this point winds round at the bottom of the cliff, passing under and close to Lady Londonderry's picturesque residence. From its castellated style, this building harmonizes well enough with the scenery.

From Glenariff, round by Carnlough and Glenarm to Larne, the scenery continues of the same general character. Lofty cliffs, partly of basalt, partly of chalk, approach the sea, but the road is everywhere close to the coast, the cliff having often been cut away to make room for it. At frequent intervals, there are breaks admitting of a view of pretty glens running up into the country. Out towards the sea the high land of Scotland in the distance and the little rocky islands called the Maidens, with their two lighthouses, are always in sight, and the projecting tongue of land forming the northern boundary of Belfast Lough almost seems as if it belonged to some island at a distance from the mainland.

But where, after all, the reader may ask, are the Irish volcanoes? What is the evidence that all these contrasts of black and white, these numerous varieties of curious mineral of which little collections are thrust into the hand of every tourist, by all the men, women, and children of the country, mean anything so serious as earthquakes, craters, and melted rock? This very natural and reasonable question let us now endeavour to reply to.

Certainly there is no record of volcanic action even in the

most ancient of the historic records of old Ireland. Certainly also if we could know all that the oldest Phenicians, or yet earlier visitors, have seen in those times when the native tribes inhabited the crannoges, and dwelt in lake-villages, killing the wolf, and even the great-horned elk, with flint-tipped arrows and stone hatchets, we should be left in equal ignorance concerning these phenomena. But it is none the less certain that the events took place, and that, at a period historically remote enough, but geologically modern, the whole north-east of Ireland and the western islands of Scotland were parts of the bottom of an ocean, beneath which subterranean thunders growled, and occasionally and at no long intervals the upheaving force rent the solid rock, and poured through the fractured crust a fluid glass precisely identical with the lava floods of Vesuvius and Hecla. But as the molten mass was always thrust up under the pressure of a considerable depth of water, it was spread evenly over the ocean floor in a comparatively thin sheet, and both water above and chalky mud below being exceedingly bad conductors of heat, the thicker deposits must have taken a very long time to cool. Now it is well known from observation that the sand at the bottom of an iron or other furnace left exposed to intense heat for a long time, solidifies into a kind of glass, and when taken out breaks up into small groups of columns. These are the simple and inevitable results of the change produced by long-continued heat, and slow cooling. The columns are tolerably regular, and always tend to the six-sided form. A similar though less perfect construction is seen wherever melted rock cools slowly, and the more gradual the passage into a solid state—the more uniform the conditions, and the heavier the pressure under which the operation is carried on—the more compact is the resulting mass, and the more perfect the concentric and columnar structure. For after all the latter is the result of the former. When a simple mineral is allowed to arrange itself naturally, it crystallizes, or forms into a group of distinct angular shapes, often beautiful, and always reducible to the same mathematical form. When a mineral mass or rock, made up of several minerals not very regularly put together, is melted and cooled again, it tends to form into rounded lumps or spheres, and if allowed to form very slowly, these seem made up of successive coats, like the coats of an onion. After long exposure to the weather, this tendency always shows itself in such rocks as lava. In cases where the conditions are very uniform, these spheres seem to have been checked in their tendency to form perfect spheres by pressing against each other. Since, however, in a layer of shot or round solid balls, each one touches and is touched by

the adjacent solid balls at six points, leaving interspaces (a fact very easily proved by experiment), it is clear that if the balls were soft, and lateral pressure uniform, they would be squeezed into six-sided figures with rounded terminations. But if there should be a succession of such layers, the pressure at top and bottom being considerable, and the balls plastic, a series of vertical six-sided columns would result—these columns being divided, and the divisions flattened, but still perhaps showing more or less of the concentric structure. This is precisely the case at the Giant's Causeway, and in numerous other instances where lava has been erupted and cooled under similar conditions. This explains the saucer-like top of some of the columns, and the ball-like fitting of others into the hollow socket adjoining. Thus also we account for the various chairs, with their fanciful names, already alluded to, and for the organ, the chimney, and other instances of longer and more regular columns; and thus again we are able to understand the repetition of the columnar structure in various parts of the same bed of rock.

It has been found that from various parts of the cliff of basalt near the Causeway, curious specimens of minerals may be obtained. Among these are beautiful chalcedonies and opals, rich agates, and not a few less durable, but even more beautiful crystals. These are usually found in the bubbles or cavities of particular bands of rock, *not columnar*. Some of these bands are crowded with innumerable cavities, generally small; others contain larger specimens, but not so many in a given space. The contents of the cavities are the gems of the Causeway, and are identical with the gems of Lough Neagh. Some of the best specimens are found close to a bed of altered woody matter once worked for fuel. Others are from a bed near a deposit of fine red ochre. It is not difficult to explain the origin of these minerals. Where the lava has been poured out under deep water, the conditions of cooling are regular, and the rate slow. In these cases there are either no cavities or very few, but the rock is broken up into columns, and then again into slices. Where, however, the water has been shallow, and the cooling much more rapid, as must have been the case when the rock rests on altered trunks of trees, the lava has become more like pumice, and full of bubbles. Originally, perhaps, these were full of gas, but they have since been filled with crystals derived from the surrounding rock. These numerous blebs and cavities completely alter the appearance and texture, and even affect the colour of the rock, which there much more resembles the lava of Vesuvius than the compact mass of the Causeway columns.

The reader will now understand the theory of the Giant's

Causeway, and the nature of the evidence on which we assert that it represents a condition of the earth when the volcanic fires, that have now retreated to Iceland, burnt fiercely beneath the British Islands. There is, indeed, no great accumulation of ashes or other products indicating a volcanic mountain on land; but submarine volcanoes, such as still burst forth occasionally, are not less real than Etna and Vesuvius. The story enacted thirty years ago in the Mediterranean, between Sicily and the site of old Carthage, will illustrate the nature of the case. There, in water a hundred fathoms deep, ships passing over the surface felt earthquake shocks which extended to the land of Sicily. Columns of water were thrown into the air sixty feet high and half a mile in circumference, columns of steam succeeded them, reaching nearly 2000 feet above the sea level, and at length a solid island appeared. The island grew till it was more than three miles in circumference, and ninety feet high; but very soon it was reduced by the waves, and at length disappeared, and within a few months from the first appearance the whole affair had terminated. Perhaps some such history may have belonged to the north-eastern Atlantic, before the ice from the polar land chilled the islands that then existed, or the glaciers and icebergs, loaded with gravel and mud, were caught and stranded on the shoals which were afterwards to be the hills and plains of the British Islands. That there was a time, long after the chalk-mud had been deposited and hardened, when the ocean floor of chalk and flint was rent to admit the passage of molten rock, the Giant's Causeway clearly proves. That this time, though so recent, compared with the formation of many well-known rocks, preceded the epoch of doubtful though vast antiquity, when men and elephants, tigers and rhinoceroses, lived in northern Europe with the beaver and the wolf, the reindeer and the large-horned extinct Irish elk, is equally beyond cavil. Thus the study of the Causeway is an instructive chapter in geological history, and the remains of Irish volcanoes are of some value as records of past events, as well as in their quality of introducing a peculiar rock, and framing some of the most singular scenery on the shores of the British isles.

NATURAL HISTORY OF ENTOZOA.

One of the most astonishing arrangements of Nature is the production, in enormous quantities, of a class of animals destined to live during a part, or the whole of their existence inside creatures of a higher organization, boring into their structure, imbibing their juices, and often causing their decease. We do not wonder very much that a cat should catch a mouse, a hawk pounce upon a sparrow, or a fox carry off a goose to replenish his larder in the woods. In such cases the carnivorous assailant behaves very much after our own fashion, and an absence of culinary practices marks the chief difference between his mode of conducting the commissariat department and that which pertains to the human kind. Making, now and then, a dainty exception, the larger carnivorous animals munch away at the carcases of their victims till every edible portion has disappeared. Quite different from these magnates of destruction, who devour their fellow-creatures wholesale, is the humbler class of anti-vegetarians, who get their living as parasites, dealing in a small retail fashion, a little bit at a time, with the bodies of larger animals, which they attack from within, or assail from without, according to the precise nature of the food they require, and the implements of destruction they possess. External parasites belong to various families and orders of animated beings, those best known being furnished by the insect tribes, though others, equally common and interesting, are small cousins of the crabs. Passing to the internal parasites, we find amongst them representatives of distinct classes. We note, for instance, that many insects lay their eggs in the bodies of other animals, while the multifarious creatures known as intestinal worms supply the most remarkable instances of eccentric forms, wonderful transformations, amazing migrations, and insidious assassinations of their unfortunate hosts. Our friend, Dr. Cobbold, is remarkably fond of considering the superior animals, man included, in his capacity of "host," or hostelry for parasites of this kind. Although eloquent in warning us against the dangers of allowing ourselves to become a house of call for incipient tape-worms out of place, or for other vagabond entozoa in search of such board and lodging as our livers, muscles, eyes, brains, or intestines may afford, he delights in contemplating the curiosities of their structure, and draws their portraits with such affectionate skill as to make good their pretensions to beauty of a singular, but easily recognizable sort.

It is convenient to consider the entozoa as one group; but when we come to study their organization, we find that a

scientific system of zoological classification would range them in different ranks. If all are comprehended under the term Helmintha or Helminths, three separate classes will follow, as in Dr. Cobbold's scheme; one having no distinct intestine, is appropriately named *anenterelmintha*, an appellation which is a simple statement of the fact. More highly organized than these, are others with elaborate internal organs hollowed out of the general tissue, and not occupying special cavities. These are the *sterelmintha*, or "solid worms," of Owen; and then we find another set whose organs are situated in cavities, and which constitute the *cœlelmintha*, or "hollow worms," rounded and threadlike in form.

The intestinal worms (entozoa) offer very remarkable illustrations of those methods of reproduction that are allied to the vegetable plan of *budding*, and which are very common in the lower ranks of animated being. Among the higher forms of animals there is no offspring unless a true egg is fecundated by the action of the male, and the germ it contains gradually grows into a resemblance of the parent form. The superior vertebrates bring forth their young in a tolerably perfect state, the preparatory work of their construction being carried on inside the maternal organism. Lower vertebrates, such as oppossums and kangaroos, give birth to their offspring in a very unfinished condition, and they are suspended to the teats of their parent and left to suck their way to shapeliness in that warm and comfortable nursery, the *pouch*. Very great are the changes which the embryo of the highest creature undergoes before it is permitted to make its entry into the world; but they are concealed from the ordinary eye, and only made known to us through the difficult researches which the physiologist carries on. If, however, we turn from the vertebrates to the insects, we come at once upon the exhibition of remarkable transformations effected under our very eyes. We see the worm-like larva become a chrysalis, and the chrysalis in its turn grow into the perfect insect, and thus we have afforded to us the striking lesson that the same individual creature can exist under forms and conditions so different, that nothing but the most rigid demonstration could convince us that the wriggling grub, the quiescent pupa, and the lively flying insect were really the same animal at different stages of its being. Continuing our researches, we find that the pupa state is not in all cases an inactive one, but we recognize in the transformable creatures the offspring of an egg fecundated in the usual way.

Proceeding still further in the inquiry, the common aphis, or plant louse, affords us illustration of another mode of multiplication; and among infusoria it is common to

see an individual splitting himself into two parts, each rapidly becoming a perfect creature of its sort. In the case of the dividing animalcule, the process is patent to all who look on; but the aphis riddle was only deciphered by great labour and pains. A female aphis, retaining her spinsterhood and virginity, gives birth to a succession of infants like herself, and only towards the close of the season does she take a husband, and set about the business of family-making by the orthodox method of fecundated eggs. It required the collection of a great many scattered facts to account for such proceedings, but it was discovered that the little ones produced by the aphis spinster were repetitions of herself by a process much like the budding of plants. We usually find a bud remaining attached to the parent plant, and growing up to maturity without leaving its mamma. This remaining with the parent is not, however, necessary, as the gardener shows when he removes a bud and causes it to grow in another place. Certain water plants also drop buds or *bulbils*, which, if they fall in suitable quarters, gradually grow to the parent form. Plants grown from buds produce fresh buds in their turn, and animals grown from buds have a similar power of repetition.

Up to the present we have only considered instances of offspring of the bud kind, which resemble their parents as soon as they are mature; but Nature furnishes us with a vast number of instances in which this kind of offspring developes into something so unlike its parent, that it could never be imagined to proceed from it, if the fact that it did so was not well ascertained. It would take us into too wide a field of inquiry to pursue this investigation at large, but we have arrived at two important facts*—first, that certain creatures give rise to offspring that bear the same relation to the parent that a bud does to the tree from which it grows; and, secondly, that these budded children may grow up to resemble, or not to resemble the parent form. In many cases such creatures do not contain the organs required for reproduction by true eggs. If these facts are borne in mind we shall be able to understand certain highly curious proceedings of the intestinal worms. Let us, for example, follow Dr. Cobbold's account of the fluke worm, called *Distoma militaire*. The readers of the INTELLECTUAL OBSERVER need not be told what a "fluke" is, and if any have forgotten it, let them turn to an article by Dr. Cobbold (vol. i. p. 25).

Referring to the splendid work† which Dr. Cobbold has just

* Those who wish to pursue this inquiry, should read Professor Lawson's translation of Quatrefage's *Metamorphoses of Man and Animals*.

† *Entozoa: an Introduction to the Study of Helminthology, with reference more particularly to the Internal Parasites of Man.* By T. SPENCER COBBOLD, M.D., F.R.S., Lecturer on Comparative Anatomy at the Middlesex Hospital. Groombridge and Sons, Paternoster Row.

given to the public, we find that "in the adult or sexually mature condition the *Distoma militare* produces a limited number of oval-shaped eggs (Fig. 5 *a*), which, after the usual process of yelk segmentation, give birth to an oval, free-swimming, and finely ciliated embryo (*b*), the latter subsequently developing in its interior an oblong organism called a sporocyst (*Scolex*, Van Beneden). All the distomes commence life in this manner, but Van Beneden is not absolutely certain that the ciliated embryos here drawn from his figures (*b* and *c*) were produced by the ova of the particular distome now employed for illustration."

This does not matter for our present purpose, as the process

Fig. 5.

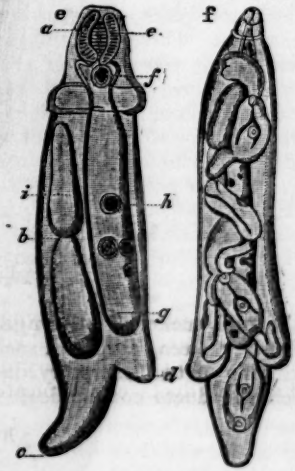


Fig. 6.

in all flukes is essentially the same, and the "sporocyst" at the time of its separation from the ciliated embryo presents a very simple appearance (*d*), showing a sort of head and body, the latter containing a digestive tube or cœcum in its interior. There is likewise a slight fissuration of the caudal end, indicating the first rudiments of two appendages, which, in a more advanced condition of the sporocyst, look like a pair of imperfectly fashioned limbs. . . . In the next stage (Fig. 6 *e*), we have a well developed head (*a*) and body (*b*), the tail (*c*) becoming pointed and strongly pronounced. In these sketches *f* represents an œsophagal bulb, *g* the stomach, and *i* imperfectly developed offspring called *cercariæ*, which abound in the interior of the sporocyst.

Fig. 7 *g* represents a fully developed cercaria, in which *a*

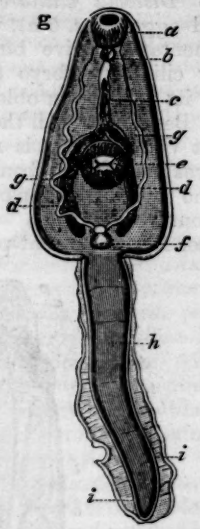


Fig. 7.

is the oral sucker, *b* pharyngeal bulb, *c* œsophagus, *d d* two alimentary cœca, *e* ventral sucker, *g g* water vascular system, consisting of two excretory ducts, *f* a contractile vesicle by which the ducts communicate with the external surface, *h* the

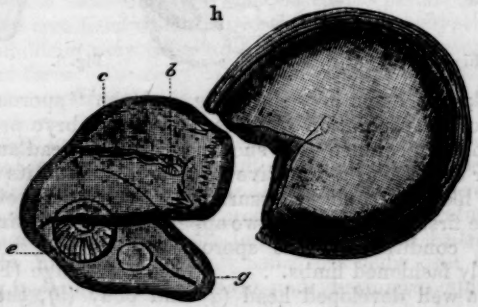


Fig. 8.

tail, with fringe *i i*. Before this cercaria becomes sexually mature it passes through the stage represented in Fig. 8, having

previously *encysted* itself. The drawing represents the escape from the cyst.* Fig. 9 represents the young *Distoma militare* in a sexually immature state. With the help of previous descriptions the several parts will be easily recognized. Greater complications than those we have mentioned occur in the reproduction and development of these worms; but for full details we must refer to Dr. Cobbold's work.

Fig. 9.

According to Pagenstecher—as cited by Cobbold—the eggs of the *Trematoda*, to which the flukes belong, vary in size, form, and colour. When mature they contain a ciliated or non-ciliated embryo. These eggs are, by various means, conveyed to the bodies of mollusks, and the germs they contain are developed into what are called "nurses," some of which are more highly organized than others. These nurses produce offspring of the bud sort. "Tailed trematode larvæ (*cercariæ*),

* *a* Mouth, *b* cephalic sucker, *c* pharyngeal bulb, *d* œsophagus, *e e* digestive cœca, *f* coronal spines, *g* contractile vesicle, *h* water vascular vessels, *i i* yelk-forming glands, *k l* cellules from which other reproductive organs will grow.

as well as *rediæ* (or nurses), are developed within the rediæ, this variation of nurse-contents probably depending on the season." "When the immature contents of both nurse-forms (*i. e.*, of sporocysts and rediæ) are accidentally set free, and are situated within the organs of nutrition of a living host, then they appear prepared to develope themselves anew into nurse-forms. . . . Some nurses are likewise capable of multiplication by division and budding."

These larval forms only exist in a few hosts, and most of them dwell in only one species of animal, but a migration is indispensable to the creature's development. When it finds itself in the right place sexual organs are developed, and the cycle of reproduction starts again with the appearance of true fecundated eggs.

Zoologically speaking, a fresh individual is the result of the development of a fecundated egg. Each genuine individual thus starts from two parents, but all the offspring of the *bud sort* merely constitute one individual in a divided state. Thus we see it is zoologically possible for the *same individual* to be *in several places at the same time.*

It is remarkable that these entozoa could not reach their full development and perpetuate their race, without the existence of more than one creature of higher organization than themselves on whom they can prey. Let us, to illustrate this, look to the history of one of the common tape-worms (*Tænia solium*). A long string, or colony, of tape-worms is called a *strobila,* and the separate joints *proglottides,* or zooids. "The anterior segments form the head and remain barren; those at the tail end become mature, are capable of living independently of the colony, and develope eggs containing embryos or *proscolices,* furnished with hooks. These latter become metamorphosed into *scolices,* or nurses, representing the well-known cysticercal state which, in its sterile or aborted condition, forms the common *hydatid.*"

Cestoid parasites are not common amongst reptiles, but they abound in the vertebrates, ten kinds devoting their attentions to man. Birds, fishes, cephalopods, and jelly-fish are likewise known to act as hosts. The mature joints of the common tape-worm are voided by its host, and the embryos get dispersed. If a pig comes in the way of such an embryo and swallows it with his food, it bores its way into his flesh, producing the "measles" known to pork, and when this objectionable article is eaten raw or underdone by a man, the foundation of a tape-worm colony in his interior is at once successfully laid. Should a resting larva (cysticercus) get into the brain a fatal result ensues.

The eggs of these creatures, being abundant and small, are

easily blown about by winds or carried by the legs of insects, and thus, Dr. Cobbold teaches us, they may be dropped on our food, and we may swallow them unawares. In the case of the *Tænia echinococcus* the dog acts as the preparatory host, and in due time hands his dangerous guests over to his master—man. This is a fertile source of death in Iceland.

Dr. Cobbold advises scrupulous care and cleanliness in regard to domestic animals. Neither dogs nor pigs should be allowed to eat any filth they can pick up, and when animals are infected they should be appropriately physicked and their excreta burnt. It may be added that eating raw unwashed vegetables is a very likely mode of conveying the germs of dangerous parasites into the human frame.

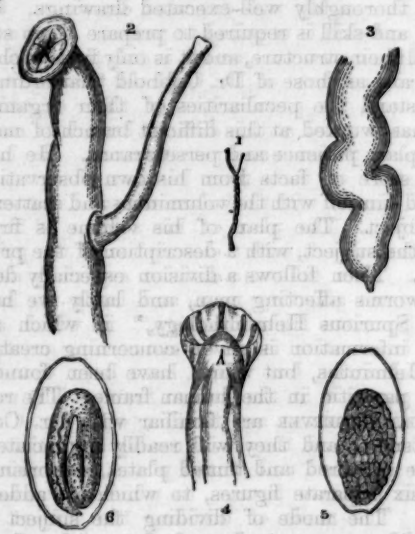


Fig. 22.—*Sclerostoma syngamus*, Diesing.—1, Male and Female; nat. size. 2, Upper part of same magnified, showing six-lobed circular lip of female, and the male attached to her. 3, Lower end of the body of female, mag. 4, Ditto of male, inverted, mag. 30 diam. 5, Mature egg, × 220 diam. 6, Egg, with contained embryo, × 220 diam.

Every keeper of poultry is acquainted with the "gapes," but all do not know that this disorder is due to the unfortunate fowl having to play the part of host to a parasitic worm. This creature belongs to the *Nematoda*, or threadlike worms, and we are able to give its portrait from Dr. Cobbold's work.

Its favourite residence is the trachea of common poultry, or of certain wild birds. Dr. Cobbold considers that in the exit of

the young from the egg, they may get into the bodies of certain insect larvæ, or even of small land mollusks; but he "thinks it more likely that they either enter the substance of vegetable matters, or bury themselves in the soil at a short distance from the surface." Salt, a weak infusion of tobacco, or turpentine will kill these worms, and they may be extracted, by means of a feather, from the throat.

In the preceding observations we have made free use of Dr. Cobbold's book, which demands a special notice at our hands. It is a splendid volume. Indeed, very few scientific works will compete with it for elaborate and beautiful illustration. This is a feature of great importance, as the entozoa can not be studied with any sort of convenience except with the aid of thoroughly well-executed drawings. Considerable knowledge and skill is required to prepare them so as to make them reveal their structure, and it is only from such exquisitely-made portraits as those of Dr. Cobbold that ordinary students can understand the peculiarities of their organization. Dr. Cobbold has worked at this difficult branch of natural history with exemplary patience and perseverance. He has added an important store of facts from his own observations, and has familiarized himself with the voluminous and scattered literature of the subject. The plan of his volume is first to give a sketch of the subject, with a description of the principal kinds of entozoa. Then follows a division especially devoted to the parasitic worms affecting man, and lastly we have a section entitled "Spurious Helminthology," in which a variety of important information is given concerning creatures that are not true Helminths, but which have been found, or represented, as parasitic in the human frame. The readers of the Intellectual Observer are familiar with Dr. Cobbold's skill as a draftsman, and they will readily appreciate the value of twenty-one coloured and tinted plates, comprising a hundred and fifty-six separate figures, to which are added eighty-two woodcuts. The mode of dividing the subject adopted by Dr. Cobbold, appears to have had special reference to the convenience of medical men, whose attention to the subject is indispensable, and who can in no other publication obtain such complete information concerning the character of the parasites, the evils they cause, and both the preventive and the remedial means that it is most desirable to adopt.

There is still a great deal to be searched out in the natural history of the entozoa, and it will prove a great advantage to English students to have in their own language a work executed with so much care, and bringing to a focus an amount of scattered information that requires a knowledge of many languages, and the labour of many years to collect.

ON CONSTRUCTING GEOLOGICAL MODELS.

BY THE REV. J. D. LA TOUCHE.

In many parts of the country the results of the physical disturbances of the earth's surface are so strongly marked, that an accurate representation of them by a model would afford both interest and instruction. A geological map shows the area covered by the different classes of formations, and by means of the little arrows by which the Ordnance surveyors indicate the dip of the rocks, may give a faint idea of the physical features of the neighbourhood; but to obtain a distinct notion of the causes which have shaped the surface, have elevated the hills, have depressed the valleys, of the primeval streams which have denuded the whole; the faults, the fissures, the action of igneous matter and the other innumerable forces which have played a part in the history of the earth's crust, there is nothing so good as a model accurately constructed according to scale, and coloured so as to show the various strata and their inclination. A short account of how such a model can be made may therefore be interesting, especially as the means of doing so do not seem to be generally known; at least, when I first attempted to put my design of making one into execution, I found it rather difficult to obtain such information as would enable me to set to work. Indeed, the plans which I have adopted may, though I have found them quite effectual, be inferior to others in use, in which case I shall be thankful to be better informed.

The instrument indispensable in making the preliminary survey for this model is a level of some kind. I have been fortunate in obtaining the use of an excellent engineer's level —an expensive instrument, costing some £12 or £15. A drainer's level (the cost of which would be £1 10*s*.) would, however, answer the purpose very well; and first, since it is necessary to keep this instrument constantly in adjustment, a short account of how this is to be accomplished may be desirable, taking for this purpose the more accurate of the two kinds of level I have mentioned, since whatever corrections are necessary for it, may be easily applied to the other.

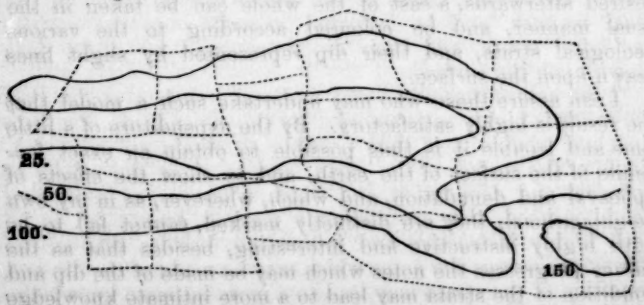
These corrections consist of two, the first being to secure that the bubble should always rest in the centre of the glass tube in whatever position it may be turned (for it revolves on a vertical pivot); and the second, that when the telescope is looked through, the bubble at the same time resting in the middle of the tube, the hair which will be seen bisecting the field of vision, may indicate an exact horizontal line. The

first of these corrections is easily made, the level being furnished with screws at each end, by which it can be gradually raised or lowered, so that however turned the bubble may rest steadily in the middle of the tube; but the second and not less important adjustment is a little more troublesome. It will be easily understood that though the glass tube itself may be quite correct, the horizontal hair in the telescope may be either higher or lower than the true level, so that all the readings taken on the levelling staff would be in error; and yet, however much this line may be out of adjustment, it is possible, by taking the elevation of two points equally distant from the level, to ascertain two exactly horizontal positions by which to correct the position of this hair. Accordingly, upon any tolerably even piece of ground, measure off about four chains, and set up the level in the centre of the line thus formed, and adjust it; then make an observation of the levelling staff (a piece of wood fourteen feet long, divided into feet, tenths, and hundredths of feet), placed at one end of the line, and again an observation of it at the other; one of these readings subtracted from the other will give the true difference of level of the two spots upon which the staff has been placed; now remove the level and erect it over one of these spots, and measure upon the staff the exact height of the eye-piece, which is of course the exact height of the cross hair inside, then by either adding or subtracting the difference previously procured, according as the further point is lower or higher than that at which we now are, we get what the telescope should read if the cross hair were in its proper place; if it is not, it can readily be corrected by the screws which will be found on the telescope tube near the eye-piece.

Our instrument being now ready for use, we proceed to take with it what are called contour lines, or lines of equal altitude, all over the country of which the model is to be made. To do this, a map of the district is first procured: a tracing on prepared linen of the Tithe Commutation maps, which are drawn to the scale of six chains to the inch, answers extremely well. If such maps cannot be obtained, we must either be content with the Ordnance maps on a scale of one inch to a mile, or we must measure with a chain from each position to the next, where we take observations of the levelling staff, and also take the angles from one point to another by a compass or sextant. Not having myself been driven to these latter resources, I shall not dwell upon them now. Our field apparatus will now be complete with a levelling book, which is ruled in the following way:—

Back-sight.	Fore-sight.	Rise.	Fall.	Reduced Level.	
				100·00	Above datum.
10·56	4·35	6·21		106·21	
8·21	3·74	4·47		110·68	
2·93	6·49		3·56	107·12	
1·87	13·72		11·85	95·27	

and used, by entering in the first column the reading taken upon the staff at some ascertained point (which, to avoid minus quantities, is usually taken one hundred feet above an imaginary point below); then in the second column another reading of the staff, after it has been removed higher or lower, as the case may be, the difference between these will manifestly be the difference of level between the two positions in which the staff has rested, which will indicate rise or fall, and which, added to or subtracted from the reduced level, will ascertain the elevation of the last spot where the staff has been placed. In the above instance this would be 95·27 above datum. We thus ascend or descend twenty-five feet from the starting point, and then commence a contour, and as we proceed, transfer it, as nearly as possible, guided by fences and other landmarks, to the tracing. This contour may be taken either by moving the levelling staff up or down as we proceed, till the very same figure is observed on it as we started with—or by using the levelling book as before; only instead of ascending or descending we keep to as nearly as possible the same elevation, always taking care to register the figure observed with great care, whenever we move the level, and again when the staff itself is moved. The same operation is repeated at heights of 50, 75, 100 feet, and so on, so that at last our map is covered with lines after this manner.

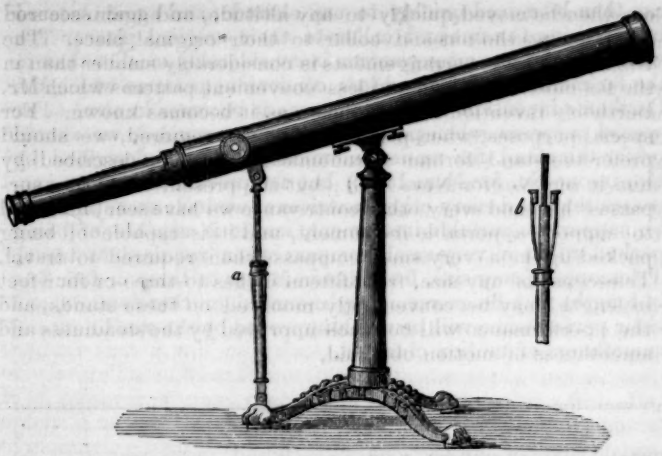


The next step will be to reduce this map and its lines to

the scale of the model. The scale which I have adopted is as nearly as possible six inches to the mile; so that if the Ordnance map be used it will only be necessary to cover it with a number of squares, and a sheet of paper with the same number six times larger, and then copy the map from one to the other; if, on the other hand, the Tithe Commutation maps of six chains to the inch have been used, if the tracing be covered with inch squares, and the blank paper with squares of ·45 of an inch (which can be very readily marked off upon it by using a common scale of two chains to the inch), it will then be found that whatever is copied on the blank paper in the proportion of these squares, will have very nearly the required dimensions of six inches to the mile. This plan being then pasted on a board the size of the intended model, a number of strips of tin must be cut, one-eighth, one-fourth, three-eighth inches broad, and so on, allowing an eighth of an inch for every twenty-five feet in altitude. This proportion is indeed considerably greater than the truth; but in such models and in all sections it is found quite necessary to exaggerate the altitudes proportionally to the horizontal measurements, since from the position of our eyes relatively to the model, we cannot see the miniature hills and valleys as we do in nature, and require this artifice to make them look correct. However, as the proportions are always observed, no real inaccuracy results.

We must now fix these strips of tin on edge upon the board by means of small tacks, the eighth-inch strip upon the twenty-five feet contour line, the quarter-inch upon the fifty feet line, and so on till the board is covered with them, rising behind each other like steps, and following in miniature the same curves which the lines did that we traced on the hill-sides: all that now remains is to fill in between these pieces of tin with any composition, such as clay or plaster; and if it be desired afterwards, a cast of the whole can be taken in the usual manner, and be coloured according to the various geological strata, and their dip represented by slight lines drawn upon the surface.

I can assure those who may undertake such a model that the result is highly satisfactory. By the expenditure of a little time and trouble it is thus possible to obtain an exact fac-simile of the surface of the earth, and to show the effects of upheaval and denudation, and which, wherever, as in my own neighbourhood, they are distinctly marked, cannot fail to be both highly instructive and interesting, besides that as the survey progresses the notes which may be made of the dip and condition of the strata may lead to a more intimate knowledge of them, and thus to ascertaining some important facts unobserved in a more cursory survey.



THE BERTHON TELESCOPE STAND.

We mentioned in the "Notes and Memoranda" of our last number that Messrs. Horne and Thornthwaite had brought out an admirable telescope stand, the invention of the Rev. E. L. Berthon, with whose name our readers will be familiar. The nature of the invention will be rendered intelligible by the annexed woodcut. The pillar is formed of iron handsomely bronzed, and the telescope is fixed in the usual way to a cradle, having a vertical motion only. Under each foot of the stand is a roller, so placed that a gentle pressure imparts a horizontal circular movement, and enables the telescope to be readily pointed in any azimuth, and to follow a moving object, such as a ship or a star, with great steadiness. Until Mr. Berthon's plan has been tried, no one would imagine how firmly the instrument stands when not touched, and yet how easily a touch in the right direction imparts a horizontal movement.

The vertical movement affords another specimen of Mr. Berthon's aptness for devising very simple means of obtaining his object. At *a* is seen an upright steadying rod, composed of a screw working through a nut, which carries it up or down the tube attached by a hinge joint to the foot of the stand. By turning the nut at *a* to the right or left, a beautifully smooth vertical adjustment is obtained. It is far better than the usual rack and pinion, and gives a *slow* motion. When a quick one is desired, a collar covering the nut at *a* is pressed downwards, when the nut itself, being composed of two pieces attached to springs, flies open, as shown at *b*. The telescope

can then be moved quickly to any altitude, and again secured by returning the nut and collar to their original place. The vibration of these arrangements is considerably smaller than in the far more expensive and less convenient patterns which Mr. Berthon's invention must replace as it becomes known. For special purposes, when portability is not required, we should prefer the stand for an astronomical telescope, described by him in our No. for Nov. 1863; but the present invention surpasses that, and every other contrivance we have seen, intended to support a portable instrument, and it is capable of being packed up in a very small compass when required to travel. Telescopes of any size, from fifteen inches to three or four feet in length, may be conveniently mounted on these stands, and their performance will be much improved by the steadiness and smoothness of motion obtained.

THE NORTH-WEST LUNAR LIMB.—CLUSTERS AND NEBULÆ.—OCCULTATIONS.

BY THE REV. T. W. WEBB, A.M., F.R.A.S.

After a somewhat lengthened absence, it is time for us to return to our exploration of the lunar scenery, under the guidance, as usual, of MM. Beer and Mädler; and we shall proceed to examine the region lying along and near the limbs of the First or North-West Quadrant, between our last object, *Cleomedes* and the *North Pole*. From *Cleomedes* then, No. 1 in our Index Map, we shall take a northerly course. And here it should be distinctly explained, once for all, that in our lunar journeys N. and S. are not to be understood as they would be in a diagram of a constellation, with reference to the N. pole of the sky as viewed from the earth, but as they would appear to us if we were actually on the spot—that is, with reference to the N. pole of the globe of the moon.

The first object of any importance that we meet with in this direction is *Geminus* (No. 2 in our map), a crater 54 miles across, and bounded by a ring rising on its W. side to nearly 17,000 feet above the interior. It contains two low and excentric hills. Little can be made out here in the full moon, except a brilliant but small crater, *Geminus* C, on its W. side, the landmark, under those circumstances, of the district. Beyond this little cup, still further to the W., lies a crater not far from half as large and fully as deep as *Geminus*, and of extreme interior steepness. It was named *Bernoulli*, by Schröter, who, in his earliest measurement, found an enormous depth of nearly

20,000 feet; several times afterwards, however, he could not see so great a proportion of shade, nor was the object distinct. 1794, Jan. 5, he found as broad a shadow, but only in one part of the depth. 1795, March 25, it was again much as when he saw it first. Hence he inferred, not as B. and M. say for him, a mistake, but some occasional atmospheric obscuration within that wonderful gulf. However, as they very justly remark, there must be great difficulty in the measurement of so narrow and so strongly foreshortened a cavity; and we may observe in general that the question of possible atmospheric variations would be very unfairly tried in any oblique situation of this kind.

A line drawn through the centres of *Geminus* and *Bernouilli* will point out a widely extended plain surrounded by a circular wall, but thrown into a narrow ellipse by a position so near the limb that it will be greatly affected by libration, and can only be well seen when favourably circumstanced in this respect. It is, however, a grand object, and well worth looking for. Its extent is no less than 110 miles, and its interior contains a chain of mountains, such that scarcely more than one parallel instance occurs on the visible lunar hemisphere. B. and M., whose descriptions are usually of a very unimaginative character, cannot refrain from enlarging on the beautiful effect of the sunset in *Gauss*, as this region is termed, when, shortly after the full moon, the illumination of the great wall gradually breaks up into separate portions, and these again dwindle into mere islands of light in the midst of the encompassing mass of darkness—a spectacle which is repeated on the E. nine hours after its termination on the W. side of the ring. They observe, too, what a magnificent view must be obtained from the central range of mountains in a suitable state of phasis and libration, when the enormous plain all round is sunk in night, and the far horizon encompassed by illuminated peaks, above which the Sun on the one side, and the still almost full Earth on the other, are slowly ascending into the sky.

As our object is not to weary our readers by a repetition of similar forms marked by little characteristic difference, but rather to make a selection of the most interesting points, we shall pass over a good deal of ground, full as it is of the gigantic products of forces now quiescent, merely remarking the singular darkness of a spot named *Struve*, which lies at some distance N. of *Gauss*, but further from the limb. It is not a crater, but a slightly depressed surface bordered by hills. Impossible as it may be ever to ascertain the cause of this remarkable darkness, the attention cannot rest upon it without a strong feeling of interest and wonder. Beer and Mädler observes that near its NW. edge is found a small point of 7° of brightness, but no especial elevation.

As in this region many instances occur of one of the peculiarities of the lunar conformations—the principle of parallelism, by which the details of whole districts are for the most part arranged in lines lying in the same direction, a caution appropriately given by B. and M. ought to be taken into consideration by the student. There are many cases in which an appearance of this kind is merely an optical illusion. Towards the limbs, the foreshortening of all objects in breadth, while their length remains unchanged, must naturally produce this effect; and all over the disc ridges lying N. and S. are more visible, and therefore apparently more numerous, than those running E. and W., from their power of casting shadows along their sides; and hence again in the polar regions, where the directions of the foreshortening and of the illumination act in opposition to each other, there is much less perceptible parallelism than near the equatorial limbs. But notwithstanding these causes of illusion, some portions of the moon are characterized by an appearance of this kind, the reality of which cannot be denied; and though of course it is more distinctly traceable, and more free from the possibility of deception, in proportion as we approach the centre of the disc, yet even in remoter situations there are districts where its presence cannot be overlooked. One of these we have now before us. B. and M. refer to the meridian position of the ridges in the interior of *Gauss* and *Messala** (a large flat ring-plain near *Struve* in the direction of *Geminus*) as instances of it, and add, that "though the first glance for the above-mentioned reasons can determine nothing, yet by a more accurate examination we find many remarkable indications of such a bearing. Thus many of the craters and ring-mountains to be found here are either quite open or made more accessible by a saddle-like depression exactly at the most northern or southern point, more usually at the latter, sometimes at both. Most of them show especially at these points some kind of peculiarity—an encroaching crater, a peak like a key-stone, a cleft, an excurrent ridge, a central point of union for branching heights, etc., and if, besides the optical ellipticity, a real one also occurs anywhere, it always lies in this direction. A force therefore has here operated under the surface of the moon in the line of the meridian; but did its action proceed from the equator towards the pole, or the reverse? Probably the former" (why, is not

* As a specimen of the way in which B. and M. have occasionally treated the observations of Schröter, it may be remarked that in describing this spot they have blamed him for his hasty and defective representation of it in his first volume, without the slightest mention of the additional details contained in two supplementary diagrams in his second volume, among which are included some which they state are very difficult to be seen.

specified) "though there is none of these formations that might not also be explained through the opposite assumption."

The most conspicuous object in the neighbourhood of the limb, as we proceed towards the pole, is the great wall-plain *Endymion*, 78 miles in breadth: from its position it is much affected by libration, which may carry it 180 miles from its mean place towards the centre of the disc, or as much the other way towards the limb. This has a great influence, not merely upon the perspective of its form, but upon the tint of its interior, which in the former case has but $1\frac{1}{2}°$ of light, in the latter, at least 1° more. There is a space of nine or ten miles broad all round the inside of the wall, which has, like the wall, 5° of light; and the grey tone is always deepest, and this border most distinct, on the side furthest from the limb. Such remarks may at first appear unimportant, but in fact where we know so little, we cannot tell what may ultimately prove worthy of notice, and suspicions begin to be entertained, as we shall find hereafter, that possibly markings of this nature may not be in all cases invariable. Nothing further of interest is visible in the interior. The wall is terraced on both sides, and is very irregular in height. The highest summit towards the W. rises to about 15,000 feet. I have seen the interior, near the terminator in the crescent moon, crossed by a great pyramid of shade, projected probably from this peak.

On the E. and SE. of *Endymion* lies a tract of country full of low hills, where a double parallelism may be distinctly traced among all the details—the principal line of direction to SSW. being crossed by another to SE.; these lines, however, though not far from perpendicular to each other, form but an acute angle to the eye in perspective.

Atlas (No. 4 in our map), together with its neighbour *Hercules* (No. 5) form a noble pair. It is to be regretted that the position which they occupy compels us to view them under a great degree of foreshortening, but even as they lie they are worthy of careful study. They afford a striking instance of a peculiar arrangement noted by B. and M. that two considerable ring-mountains, much resembling each other in form, size, depth, steepness, and other particulars, frequently occur in very close proximity, seeming to indicate similar and contemporaneous formation. *Atlas* is about fifty-five miles in diameter; its ring, which on the S. side is a portion of a somewhat smaller circle than on the N., exhibits a lofty central ridge, studded with peaks, and accompanied on either side by terraces, buttresses, ravines, and basins, for a considerable distance. It reaches its greatest height of nearly 11,000 feet on the N. side. The grey interior contains a row of hills, of which the loftiest occupies the centre. It is, perhaps, deserving of record that

Schröter, who had supposed that what he calls the central hill was of uniform height, found with his 27 foot reflector, 1794, Jan. 6, that it had two small summits, one towards each end; June 4, however, nothing could be perceived of these, but in the centre there was a little bright elevation, that, perhaps, included a minute indistinct crater. What is very remarkable is a very dark spot of a roundish form in its southern part; on the other hand, a region just outside the wall to the W. containing a small mountain, *Atlas a*, of no peculiar height or steepness, glitters with 9° of light in the full moon. At a short distance N. lies a small crater, *Hercules* A, worthy of notice for its extraordinary steepness, through which it retains its shadow longer than its colossal neighbours.

Hercules is about 46 miles in diameter, encompassed by a ring equally elevated with that of *Atlas*, and doubled in places, especially on the E. side, where there is a secondary interior and little less lofty chain, crowned like the principal range with peaks arranged at almost regular intervals. This exhibits a magnificent appearance about three days before the Last Quarter. In the interior, but not in the centre, lies a remarkably distinct crater of 8° to 9° in Full Moon. Another may be occasionally detected in the S. side of the ring.

Notwithstanding the immediate vicinity of these two grand foci of eruption, it is observable that neither has produced any disturbance in the other's form.

I have seen these objects very well at different times, varying from three to six days after New Moon, and about four days after Full. But it is to no purpose to affect precision in such estimates, as they are liable to so much interference from libration. The aspect of this region under a high illumination is especially curious, and deserves a more detailed examination than appears to have been given to it by B. and M.; in fact, the topographical study of what we may for convenience sake term the "local colouring" of the moon, has hardly as yet been begun. As far back as the year 1826, I remarked that the interior crater in *Hercules* was larger than as it has been twice drawn by Schröter; but subsequent experience has taught me to be cautious as to comparisons of this nature. This object, however, affords an excellent example of an arrangement so frequent that it may be termed a general law upon the lunar surface, that among the products of eruptions whose successive date is self-evident, the more recent are also the more reflective.

This is a very suggestive fact, and deserves attentive consideration. One obvious explanation would be the chemical action of an atmosphere which may be presumed to exist, however rare and difficult of detection.

CLUSTERS AND NEBULÆ.

The next object will, perhaps, cost us some trouble in finding, but we shall certainly not regret it, if sufficient optical power is at our command. We must first of all turn to the fine pair, *ζ Aquarii*, No. 66 of our Double Star List (INTELLECTUAL OBSERVER, December 1862, p. 375). A little *p* the triangle including it, we shall see a 3 mag. star, *a Aquarii*, and some way further *sp*, another similar to it, *β* of the same constellation. We must now make out *ε Pegasi*, No. 65 (as above), which was recently our guide to the cluster 15 M, and in a line between *β Aquarii* and *ε Pegasi*, about ⅓rd of the distance from the former, we must sweep about till we perceive a nebulous speck in the finder. Unfortunately it is not at first sight very unlike a 6 mag. star, of which there are several in this region; so that we cannot be sure of having it at once, like some of our recently-examined clusters; but it is well worth while to attack every suspicious-looking object in succession, till we have got the right one. It will be our—

23. *The cluster in Aquarius*, or 2 Messier; discovered by Maraldi while looking after a comet in 1746. With a low power we shall see it as a bright nebulous globe, with perhaps some appearance of resolvability. Its future aspect, as we seek a further acquaintance, will depend upon the capability of our telescope. H of course resolved it, and it is one of the few objects on which we read of the working of his 40 foot reflector. I have seen it distinctly granulated with 144 upon $3\frac{1}{10}$ inches; with $5\frac{1}{2}$ inches its brightness makes it a superb object, and one of the very finest of its class; resolvable with any power, but merely so far as to show its starry composition. A very fine silver-on-glass speculum, the workmanship of Mr. With, of Hereford, 8 inches in diameter, goes deeper into it, and brings out, though feebly, a wonderful picture of creative energy. To comprehend its full glory, the resolving power of a still greater aperture should be brought to bear upon it. Sir J. Herschel, in the use of an $18\frac{1}{4}$ inch speculum, speaks of it as "a most glorious cluster of stars 15 mag. compressed up to a blaze. Its most crowded part takes 6 s. to pass the wire, but there are straggling stars, although few, of the same size as the rest. There must be thousands of them. The total light of the cluster not exceeding a star 6 m., it follows that several thousand stars 15 m. =1 of 6 m." At another time he calls the stars 12, 13, and 14 mag., and says, "they are evidently globularly arranged, and not internally condensed towards the centre more than the spherical form would make them appear to be; but in the middle they blend into a blaze of light. It is like a heap of fine sand! With 9 inches

aperture I can just see the stars; with 6 it is resolvable." The effect of a still greater profusion of light is somewhat to alter its aspect. With twice H.'s aperture, though not four times his illuminating power, owing to the Newtonian arrangement being employed instead of the front view, the Earl of Rosse found a greater intermixture of large and small stars, giving a uniform roundish centre of large ones, with a sudden set-off, beyond which were a great number of small ones with a few large ones intermixed; the outer edges having a tendency to run in rays.

There can scarcely be a more wonderful sight, of its kind, than this starry globe; or one that gives a stronger impression how little it is that we know of the true nature of what is surrounding us on every side. That aggregation of several thousands of suns is obviously bound together by some law of inter-dependence, of which we, the attendants of a solitary star, have no idea whatever; they are evidently as it were one family dwelling apart, wholly insulated from the rest of creation, and jointly inhabiting a separate and circumscribed region in the immensity of space. It is impossible to look upon that most beautiful mass of stars, even in its feeble telescopic representation, without feeling how little pretension our own system can have to a central or dominant position among the works of God; and how amazing would be its aspect, if we could view it from a point where its proportions to the unaided sight would swell out to those of a globe of 15° or 20° in diameter. We can indeed expand it artificially to that apparent size. A power of 600 or 800 would spread it to that angular extent. But how far would that dim substitute fall short of the magnificent original, with a brightness, even in the gigantic telescopes of Poulkova or Harvard, diminished to $\frac{1}{64}$th* of the reality! And what words could express the splendour of the spectacle in the interior of that globe! "Imagination cannot but picture," as Smyth remarks, "the inconceivable brilliance of their visible heavens, to its animated myriads." It is true that in our total ignorance of the real distance of these clusters from our system, we can form no notion of the amount of their internal compression, but

* The mode of obtaining this result is as follows:—Assuming a diameter of 1½′, as given by H, this will be enlarged to 15° by a power of 600. The area of a 15 inch object-glass is 5625 times greater than that of the pupil of the eye, admitting the latter, as usual, to be ⅛th of an inch in diameter, and if no allowance is made for loss of light in the instrument, by so much will the brightness of the telescopic exceed that of the natural image. But, as light diminishes with the square of the distance, at $\frac{1}{600}$th of the distance we should have 360,000 times the light: and this sum divided by 5625 previously obtained, gives 64 times the brightness of the natural object as compared with the telescopic image, even under these very favourable circumstances. With a 6-inch object-glass, the difference would amount to 400 times.

there can be no question that it indicates an amount of light, and probably of heat and all other solar influences, strangely contrasted with the condition of our solitary and partially illuminated system. Here, however, we live, and enjoy existence; there, in all probability, encompassed by suns in every direction, we should soon perish in the blaze. But these clusters are not only objects of the highest magnificence, but of profound mystery as to their mode of persistence. From the orbital motions of binary stars, as well as from all considerations of analogy, we are led to infer a diffusion of gravity as universal as that of light; but, if so, these glorious agglomerations of suns must be in a state of progressive collapse, and advancing, however slowly, yet with gradually accelerated speed, to final destruction, or transformation into some wholly new form of being. Nothing but the centrifugal force produced by rotation is capable, under any known circumstances, of averting this catastrophe. Such would be the certain fate of the whole planetary system, such in all probability that of the binary suns, if rotation were to cease to exist. But how rotation can exist in these clusters is a most perplexing question. Sir J. Herschel, who says that "it is difficult to form any conception of the dynamical state of such a system," has indeed pointed out certain conditions under which an aggregation of this kind might maintain its stability, every separate star describing its own elliptical orbit around the common centre of gravity, and all of them returning, after a certain period, to their original situations. But those conditions, as far as our vision can inform us, are most improbable. It would be required that the space occupied should be a sphere, and that the stars should be all equal and uniformly arranged. No such specimen of symmetry seems to be known, while the instances to the contrary are numerous, and the increase of optical power usually adds to the irregularity of their aspect. And even were those improbable conditions fulfilled, Sir J. Herschel himself, in acknowledging that the law of periodicity would not comprise the external stars, seems to admit an element of disturbance and change, and ultimate ruin. It would perhaps be going too far to pronounce a definitive opinion in such a case, but it is not easy to escape from the conclusion that either gravity is not universally diffused, or the stars are formed of imponderable matter (both of which suppositions are strongly contradicted by analogy), or these systems contain within themselves the germs of destruction, a catastrophe not the less inevitable in the end, because the ephemeral existence of man may possibly never permit him to obtain evidence of its progress.

OCCULTATIONS.

This month affords several of these phenomena, which should not be neglected by the observer. The first, on Oct. 8th, will be an interesting one as regards the object, and under favourable lunar circumstances, near the time of the quadrature, when a good telescope may still be expected to show the dark limb. ρ^2 Sagittarii, 5½ mag., will disappear at 7h. 17m., and be followed by its more brilliant companion, at a little distance N, ρ^1, 4 mag., 4m. afterwards: the respective emersions will be at 7h. 48m. and 8h. 8m. The next, on the 9th, is of a yet larger star, β Capricorni, 3 mag., which will be hidden from 8h. 35m. till 9h. 28m. 14th, ϵ Piscium, 4 mag., from 6h. 59m. to 7h. 48m.

ADDENDA.—In the last number of the INTELLECTUAL OBSERVER it was stated that "sanguine stars are, without exception, so far as is hitherto known, insulated." I have since, however, found an instance in Sir J. Herschel's *Cape Observations*, where two stars, each 9 mag. and 10″ apart, are both "of a full scarlet colour." They form his No. 4649.

Those who have felt interested in the speculations as to the constitution of the sun and stars, referred to in the same paper, will rejoice to hear that Professor Donati has succeeded in seeing and measuring spectral bands in the light of the late comet. If these can be identified with those of any known elements, it is the greatest step that has yet been made towards a knowledge of the real nature of these most mysterious bodies.

PRINCIPLES OF PHOTOGRAPHY.*

BY J. W. M'GAULEY.

Management of the Light. Photography is based on the chemical or actinic action of light; the luminous rays would be inert, or even mischievous, but for the actinic rays present along with them. The green tint found in objectives, especially those of crown glass, lengthens the time required for exposure; but, as it affects the strong central rays most, it tends to equalize the action of the light over the whole field. There is reason to believe that the rays which traverse the thick part of the lens are thus deprived of half their actinic power. Much, however, depends on the kind of green that constitutes the

* This is the third article of the series, of which the fourth and concluding paper will shortly appear—the first, on "The History of Photography," is in No. 27; and the second, on "Photographic Processes," in No. 28.

tint. Yellow and red are, to the photographer, dark colours; blue and rose, bright ones. The green of leaves is inert with regard to compounds based on iodide of silver, but energetically affects those based on bromide of silver; hence, one of the advantages of using both iodine and bromine in the preparation of collodion. The sensibility of the eye to the solar rays, is greatly less than that of the substances used in photography: during the total eclipse of July 18, 1860, a photographic image of prominences, not visible with glasses, was obtained. The rays at the red extremity of the spectrum are too slow, and those at the violet extremity too rapid, to affect the eye; just as sounds may be too high or too low to be audible. Glass will not transmit freely the more refrangible actinic rays; the only solids which allow them a free passage are diamond, rock-crystal and fluor spar; water is the only fluid; hydrogen, nitrogen, oxygen, and carbonic acid the only gases. The atmosphere transmits varying amounts of actinic rays: from noon until six in the afternoon, in summer, about twice as long exposure is required as between nine in the morning and noon. Light produces a more or less permanent effect on bodies; if an engraving is exposed to the sun, and placed on a sheet of sensitized paper, it will reproduce a trace of the object on the paper. The chemical action of light is modified by the greater or less intensity of what is reflected from the various parts of an object, according as they are more or less in shade, or more or less averted; and hence lights and shades are reproduced with their proper gradations. To secure rapidity, it is necessary to condense the light; and hence, in ordinary cases, the image is less than the object. To obtain a good picture, we must have, not only a good apparatus, but a good light; those who pretend to produce as good results on dull as on bright days, deceive themselves, or attempt to deceive others.

Although no amount of excellence in the instrument will make up for insufficiency of light, its quality is of great importance. When Daguerre made his experiments, an exposure of a quarter of an hour at least was required; when the camera was improved, three minutes sufficed in similar circumstances. Short foci, and two lenses, which intensify the light, and thus give rapidity, are required for portraits; for landscapes, where the objects are in different planes, single objectives with long foci and diagrams or stops, are employed; although these increase the time required for exposure. If a portrait objective is used with a landscape, a diaphragm with a very small opening will be required; this enlarges the field, but, at the same time, enormously diminishes the rapidity. With a single lens, a larger number of distant objects are in focus; but even this is improved by a diaphragm, which ex-

cludes the oblique and marginal rays, and admits only those which fall about the middle of the lens; these being the only ones brought to the same focus.

When a cylindrical pencil of rays strikes obliquely on a lens, they describe upon its surface, not a circle, but an ellipse; and the focus of the rays at one or both extremities of the major axis is farther from the lens than that of the rays at the extremities of the minor axis. Two false foci, therefore, are the result; and the defect in the lens, thus produced, is termed *astigmatism*—a point in the object becomes a line in the image.

In repose, the eye, by its natural rotatory movement, can embrace a visual angle of from 70° to 80°. Hence, a landscape should subtend an angle of at least 60°; but ordinary instruments cannot, without distortion of the lines, embrace one greater than about 30°. Many attempts have been made to overcome this difficulty; the most successful of the expedients proposed, seems to consist in the use of two acromatic menisci, placed opposite to each other, and at such a distance that their convex surfaces, which are external, may form portions of the same imaginary sphere. Between them is a diaphragm, having an aperture which, by a simple contrivance, may be changed for a greater or a less, and is always exactly in the centre of the sphere. With such a combination, the angle is enlarged to at least 75°; and the picture obtained is so free from distortion that if the original is a flat surface, and of the same size as the picture, when one is superimposed on the other, their details will exactly coincide. Such is the extent of angle thus obtained, that the whole Hotel de Ville, of Ghent, was taken with a globe lens of this kind, at the distance of twenty-eight metres; and such the depth of focus, that distant objects were found in as good focus as those which were near. Its defect is, that spherical aberration does not allow it to be used with all apertures [*Repertoire Encyclopedique*, Dec. 1863].

Spherical aberration causes different images to be formed by the rays at different distances from the axis of the lens, so as to produce a luminous zone round its principal focus. It is directly proportional to the size of the lens; but is diminished, or even destroyed, by an eliptical or hyperbolic curvature—which, however, in practice, it is very difficult, if not impossible to produce—and by diaphragms. Hence the proper use of the latter is of the highest importance to the photographer; the diaphragm is the pupil, which, by its contraction or dilatation, regulates the quantity of light that enters the camera—the photographic eye, intercepting all useless or mischievous rays. Not only the size of the aperture, but the position of the diaphragm is of moment. It should be in front of a single lens, and between the lenses, when two are used; its distance

from that having the longest focus being the product of the longest focus and the distance between the lenses, divided by the sum of their foci; the distance between the lenses should be about the tenth part of the sum of their focal distances. There is no spherical aberration, if the right lines of the object are undistorted in the picture, and the extreme portions are as perfect as the central.

Chromatic aberration or dispersion causes the borders of a picture in the camera to exhibit prismatic colours; it arises from the unequal refrangibility of the coloured rays, and prevents the coincidence of the actinic and luminous foci. It is obviated by such a combination of convex and concave lenses, as will neutralize dispersion without altogether destroying convergence. The greater the perfection of the acromatism, the greater the difference between the optic and chemical foci.

As the quantity of light is inversely proportional to the square of the distance, it might be supposed that, the nearer the object, the shorter the time required for exposure. Such, however, is not the fact, since the longer the focus the more perfect; and hence, before the nearer objects in a landscape are done, the horizon and other distant parts will be solarized. This is not important in negatives, as the transparence is still sufficiently perfect to secure an agreeable effect in the positive.

The Compounds of Silver, Gold, etc. Pure oxide of silver is reduced by the prolonged action of light; dissolved in ammonia, it is far more sensitive. Perfectly pure nitrate of silver, crystallized, or in solution, is not affected by light; but when moist, the presence of organic matter, such as starch, gelatine, cellulose, etc., even in minute quantities, causes it to blacken in the feeblest ray; hence the use of albumen on paper. The organic matter is destroyed by nitric acid, oxide of silver being liberated; part of this oxide is decomposed by light; the remainder may be removed by ammonia, in which it is soluble. The re-action of organic matter on nitrate of silver causes paper imbued with it, unless absolutely free from moisture, to become yellow in a few hours: more vigorous pictures are obtained with paper in which partial reduction of the silver has commenced. The nature of the organic body determines the colour which results; and the effect is heightened by precipitating the organic solution with a solution of lead, which, under the influence of light, exalts the oxidation of the silver salt, applying the precipitate to the paper in the consistence of cream, and drying before the nitrate is applied. Chloride of silver is very sensitive, and it is rendered more so by the presence of a little nitrate. The colour it affords depends on the chloride used to precipitate the nitrate; in nearly all cases, however, an olive tint is produced at last; and, when light no

longer acts upon it, it will be found covered with metallic silver. Papers prepared with chloride of ammonia, or chloride of barium, and then nitrate of silver, give, when the spectrum is thrown upon them in favourable circumstances, a range of colours very closely resembling the natural; a blue, or rich lead colour, being produced between the most refrangible green and the extreme edge of the violet, and beyond this a black; but in the space of the least refrangible rays, a brown, which, under the red ray, passes into a red. It is supposed that, in presence of moisture, chloride of silver is first changed into oxide, hydrochloric acid being formed, and that the oxide is then decomposed. Iodide of silver is but little acted on by light, which, however, renders it easily reducible; it is believed to produce a catalytic, rather than a photographic effect, and to be the cause of the decomposition of nitrate, in presence of reducing agents, during development. It is more sensitive when in contact with nitrate; and, under the influence of light, suffers the same kind of changes as the chloride. Since it produces oxide, or metallic silver, the developing fluid should not contain free acid, which would combine with one or both before the latent image could be developed. Hence a developing mixture, consisting of a concentrated solution of sugar of milk, which does not act on silver or its oxide, and a small quantity of sulphate of iron, afford a good picture, after a short exposure. When the spectrum is thrown on paper containing only iodide of silver, the actinic action rarely extends beyond the green; hence green or yellow has no effect upon it. Bromide of silver, also, is rendered more sensitive by the presence of organic matter; under the influence of light, it exhibits changes similar to those of the chloride and iodide. The insolubility of the chloride, iodide, and bromide of silver causes them to be suited for photographic purposes, since it prevents them being washed away during the processes which are necessary.

The nature of the base combined with the iodine and bromine in the collodion, exerts a marked influence; ammonia, cadmium, lithium, magnesium, potash, and zinc, are the most effective. Potash labours under the disadvantage of its iodide being soluble only in weak alcohol, and its bromide being scarcely soluble at all. The compounds of cadmium are very permanent; and hence collodion prepared with them remains for a considerable time without change. Those compounds which have the smallest chemical equivalents, and which leave the silver salts in the sensitive coating in the state of greatest purity, seem accompanied by the most sensitiveness; such are the compounds of ammonia, lithium, and magnesium. Those of lithium and magnesium keep the plate moist; with those of

cadmium it dries so soon that, in hot weather, the picture can scarcely be developed quickly enough.

It has long been known that a solution of gold is decomposed by sunlight; ivory may be gilt by washing with such a solution, and exposure. When a neutral oxalate is heated with a neutral solution of gold, metallic gold is precipitated. Light produces the same effect as heat, and what at first is only a stain will go on darkening for weeks, even if light is excluded, especially in a damp atmosphere. This slow reduction which, after exposure to light, continues in the dark as long as any unreduced gold remains, is common to all the salts of that metal. The presence of chlorine, iodine, or bromine, does not appear to render the salts of gold more sensitive; but if copper, iron, lead, tin, zinc, etc., are polished and exposed to the action of chlorine, iodine, or bromine, in a dilute state, there results a weak combination which is decomposed by light, the metal being reduced. Several of the salts of mercury are more or less affected by light. Bichromate of potash is decomposed by it, when in contact with organic matter. Nor is the action of light confined to compounds of the metals; under its influence, phosphorus dissolved in hydrochloric acid is abandoned by the acid; hence all salts which are soluble in phospo-hydrochloric acid are sensitive to light when thus dissolved, though not so in other circumstances. If paper wetted with a solution of acetate of copper in phospo-hydrochloric acid is exposed under a negative, the parts acted on by light will become of a grey colour, the acetate having become binoxide; this, if the paper is exposed to sulphuretted hydrogen, will be changed to bisulphuret; the picture will very soon vanish, however, by the bisulphuret forming sulphate, unless the copper is changed for another metal, which may be effected by washing the paper in water, and then plunging it into a solution of nitrate of bismuth, to which a small quantity of acetic acid has been added.

ARCHÆOLOGIA.

DISCOVERIES AT BATH—EXPLORATIONS AT RICHBOROUGH.

It might be supposed that on the occasion of the British Association's visit to a city so celebrated in the Roman period as Bath, eager inquiries would be made after its antiquities, yet the remains of Aquæ Solis, as this place was called by the Romans, which are now visible, are very few indeed, and the inquirer cannot fail to feel disappointed. In one class, it is true, the museum of the Literary Institution is rich; those are, inscribed monuments of stone, such as altars, sepulchral stones, etc. But in the class of miscellaneous

remains, which are usually found so abundantly on Roman sites, the small collection placed in the vestibule of the museum is lamentably deficient. We can only ascribe this deficiency to the carelessness and neglect of the citizens in past times, who have allowed the objects of antiquity which must have been often found, and in abundance, to be scattered and lost as soon as found. It is to be hoped that this will not be the case in future.

Excavations for the foundations of the United Hospital have brought to light Roman remains, of which, it is to be hoped, better care will be taken. They appear to have belonged to a large mansion, which occupied the site of the present hospital, and consist of what were probably private baths, and one or two apartments. In one of these is a very handsome tesselated pavement, much broken, but still enough remains to make us acquainted with the whole design, which is very elegant, and rather peculiar in its detail. The centre is formed of a geometrical pattern, composed of small tessellæ, the colours of which are white, blue, red, black, and green, which are very harmoniously disposed and very skilfully blended into each other. The hypocaust of another room was also partially uncovered. Pottery in considerable variety, some beautiful samples of Roman glass, a coin or two, and a few other objects, were found in the course of the excavations, and are at present in the possession of the architect, who, it is understood, intends to deposit them in the museum.

The Kent Archæological Society has undertaken some important excavations within the walls of Richborough, the *Rutupiæ* of the Romans, and their principal port of landing for this island. In the middle of the interior of this citadel there is underground a rectangular building, nearly a hundred and fifty feet long by a hundred broad, and the walls of which have been traced to a depth of above thirty feet, with no appearance of being near the bottom. To discover the use and character of this building has been the object of excavations made by Mr. Boys, the Sandwich historian, in the last century, and of his relative the late Mr. Rolfe, of the same town, in 1843, but with no result. The platform of masonry which forms the upper surface of this extraordinary mass extends a few feet beyond the vertical walls of the building underneath, and is covered with soil a few feet deep. Former excavators had dug under the edge of the platform in the vain hope of finding an entrance in the side walls. Mr. Rolfe thus carried a gallery round three of the sides, and the Kentish society has continued it round the fourth, with no better result. Some suppose that this subterranean building is a mere solid mass of masonry, intended to support some heavy superstructure; but this seems so improbable, that it hardly deserves to be entertained. It is most likely that it contains rooms of some kind or other, perhaps intended for stores. The most likely course for finding the entrance seems to have been overlooked, namely, by uncovering the whole of the surface, which might be done by continuous trenching; and this plan, as we understand, has now been adopted by the Kentish society, and we cannot but hope that the result will be of an interesting and important character. T. W.

PROCEEDINGS OF LEARNED SOCIETIES.

BY W. B. TEGETMEIER.

MEETING OF THE BRITISH ASSOCIATION AT BATH.

On the evening of Wednesday, September 14, Sir Charles Lyell, the President of the Association, delivered his inaugural address, He began by reference to those thermal springs, which, from the time of the Romans, have made Bath so celebrated. He then spoke of the probable connection between volcanoes and hot springs; and mentioned that such springs generally occur where volcanic agency has caused a "fault," and also that they are of most frequent occurrence in those districts where volcanoes are either active, or have been so at a very recent geologic period. The quantity of solid matter contained in the water of hot springs was alluded to; and it was said, that if the mineral ingredients contained in the Bath waters were solidified, they would form, in one year, a square column nine feet in diameter, and no less than 140 feet in height. Although the waters of hot springs are, as a rule, destitute of the common metals, such as iron, etc., there is a strong presumption that there exists some relationship between the action of thermal waters, and the filling of rents with metallic ores. The component elements of metallic ores may, in the first instance, rise from great depths in a state of sublimation, or of solution in intensely heated water, and may then be precipitated in the walls of a fissure, as soon as the ascending vapours or fluids begin to part with some of their heat. It is possible that the metamorphism of sedimentary rocks may also be owing to the influence of hot springs. The thermal waters of Plombières, in the Vosges, were conveyed by the Romans to baths through long aqueducts. In this case, the hot water percolating through the masonry has given rise to various zeolites,—to calcareous spar, arragonite, fluor spar, and even opal. It is possible that the consolidation of granite may have taken place at less high temperatures than were formerly supposed; and the manner in which volcanoes have shifted their position throughout a vast series of geological epochs may, perhaps, explain the increase of heat as we descend to the interior of the earth, without the necessity of our appealing to an original central heat, or the igneous fluidity of the earth's nucleus. Great changes within comparatively recent periods have taken place in the climate, not only of Britain but of the whole northern hemisphere. The probable causes of the refrigeration of central Europe, during the glacial period, have to do with the alterations in the physical geography of the surrounding countries during that period. It has been shown that during that time the Sahara,—now a burning desert, sending hot winds, whose effect is to lessen the extent of the ice on the Alps,—was a sea, furnishing moisture. This moisture cooled on the Alps, probably at that period 2000 to 3000 feet higher than they are now, would in great measure account for the ancient glacier-extension in

Switzerland. In addition to these circumstances, it is highly probable that, during the icy period, the Gulf stream, at present so great a source of heat, did not visit our shores, but, owing to the different shape of North America, took an altogether different direction. The very imperfect state of our knowledge has given us as yet no proof of the existence of man during this period of extreme cold; though it has been ascertained that he flourished in Europe during an early part of the post-glacial period. Early education and tradition make it difficult for us to allow the long periods of time that must be granted for the changes which have taken place in the earth's surface. The geologic record is very fragmentary; and the more that is known of it, the more this fact is realized. In the lowest half of the series of Laurentian rocks, Dr. Dawson, of Montreal, has detected, by the aid of the microscope, the distinct structure of a large species of Rhizopod. The rocks in which this fossil—called the *Eozoon Canadense*—have been found, are as old, if not older, than any of the formations termed Azoic in Europe. Specimens have been brought to England by Sir William Logan, and are exhibited at the Association.

Thursday, September 15th.—In the section of Mathematical and Physical Science, Mr. GLAISHER read a paper on LUMINOUS METEORS. He said that numerous observations of fire-balls had been made. The largest had been seen on the night of the 5th December, 1863, and had produced a vivid impression of lightning over the whole of the British Isles. Fire-balls and shooting-stars are supposed to be loosely compacted, and in this way their want of penetrating power may be accounted for. Shooting-stars commence at 70 miles, and disappear at 50 miles above the surface of the earth. The meteors observed on the 9th and 10th of August, 1864, were in numbers nearly about the average of the phenomenon—namely, between 30 and 40 meteors per hour, for a single observer constantly regarding the sky near the zenith. They were not half so many in number as they were in 1863 on the corresponding dates. If any indication of periodicity can yet be traced in the fluctuations of this phenomenon, it is, perhaps, a minimum at intervals of eight years, which has thrice occurred, and on the last occasion in 1862.

PROFESSOR HENNESSEY read a paper on the ELLIPTICITY OF MARS. He said that the physical characters of the planet Mars have always been interesting on account of its supposed likeness in form to our own earth. In accordance with hydrostatical laws, a planet similar to Mars, and rotatory round its own axis in the same period of time, should have an ellipticity very nearly approaching that of our earth. Bessel and Johnson, observers of eminence, appear to have arrived at this conclusion, though some consider that the ellipticity of Mars is much greater. It is generally admitted that, in the neighbourhood of one of the poles of Mars, there exists a great mass of brilliant matter, analogous to a mass of terrestrial snow. This substance, if it is snow, must be situated on masses of land near the poles of rotation, and must vary in dimension as the seasons of the

planet alter. A fluid like water must exist in that part of the surface of Mars. Professor Hennessey said that, in controverting an erroneous theory of the earth's figure, he had obtained mathematical expressions for the equilibrium of a fluid like water spread over an exterior abraded spheroid, such as the earth was assumed to be. From these expressions it follows, that if the earth possessed very small ellipticity, it would consist of two circumpolar continents, with an intermediate belt of equatorial ocean; while, on the contrary, if the earth had great ellipticity, such as that assumed for Mars, the dry land would form an equatorial belt, while the poles would be surrounded with water. The attention of observers might be well directed to ascertaining which regions of Mars show the greatest predominance of dry land. Professor Hennessey's own opinion is, that no great amount of equatorial land exists in Mars, and that, therefore, the theory of its comparatively small ellipticity is the more probable.

On the same day, in the section of Chemical Science, the President, Professor Odling, gave some account of the recent agreement among English chemists, as to the combining proportions of the elementary bodies, and the molecular weights of their most important compounds. He said that Berzelius professedly regarded the single combining proportions of hydrogen and chlorine, as consisting each of two physical atoms; but since the two atoms of hydrogen, for instance, which constitute the one combining proportion of hydrogen, were chemically inseparable from one another, they were really tantamount to one atom only of hydrogen, and, as a matter of fact, were always employed by Berzelius as representing the single chemical atom of hydrogen, or its smallest actual combining proportion. Distinguishing thus, between the physical atom and the combining proportion, Berzelius' recognition of the truth, that equal volumes of the elementary gases contain an equal number of atoms, was utterly barren. But identifying the physical atom with the combining proportion, Gerhardt's recognition, or rather establishment of the broader truth, that equal volumes of all gases, elementary and compound, contain the same number of atoms, has been in the highest degree prolific. From Gerhardt's division of volatile bodies into a majority, whose recognized molecules corresponded respectively with four volumes of vapour, and a minority, whose recognized molecules correspond respectively with but two volumes, and from his proposals, in conjunction with Laurent, to double the molecular weights of these last, so as to make the molecules of all volatile bodies, simple and compound, correspond each with four volumes of vapour, must be traced the development of the matured views on chemical philosophy which now prevail. Professor Odling lamented the unsatisfactory state of chemical notation, and said that Sir B. Brodie was about to publish a plan which would be more suited to the present requirements of chemistry. He referred also to the study of isomerism, which, he said, is the chemical problem of the day, and said that concurrently with its rapidly advancing solution, will be the advance in rational organic synthesis—a subject which, at the present moment, seems to be making comparatively slow progress.

Friday, September 16th.—The Rev. G. Browne read two interesting papers in the sections of Chemical Science and Geology, respectively, on the Prismatic Formation of Ice in certain Ice Caves and Glaciers. The caves were stated to occur in the Vosges, the Jura, and Dauphiné, in France and Savoy. Some of them are 200 feet below the surface, and the ice is thickest in the deepest caves. The caves occur at altitudes varying from under 2000 to nearly 6000 feet above the sea-level. The temperature was from 31° to 36° Fahr. Some of the masses of ice were 70 feet thick. In many of the caves there is perpetual darkness, and in almost all a candle will burn without showing any evidence of a current of air. The ice forms columns and cascades in the caves, and when fractured presents a columnar appearance due to the number of prisms of which the ice is composed, and which are closely packed together. The prisms could be separated from each other, and thrust out separately, like a knot from the edge of a wooden board. The axes of all the prisms in the vertical columns lay horizontally. The ice resisted the effect of heat more effectually than ordinary ice.

On the same day, Captain R. H. Burton read a paper on the Ethnology of Dahomey. The kingdom of Dahomey is a power once very famous as a military empire. Its size and population has been greatly exaggerated. Its area is not more than 4000 miles, and its population not much over 150,000, of whom four-fifths are women and children. The "customs" of Dahomey—the time for the annual payment of charges to the king—are the seasons at which the human sacrifices take place. These have been represented as much greater in number than they really are. Captain Burton said only forty victims were offered when he was last at Agbomé. Two great peculiarities of the Dahomian social system are, the duality of the king, and the precedence of women over men. The king has two separate courts—one of women, the other of men—each with officers corresponding in rank to those of the other court. The Amazons form a body of nearly 2000. They are divided into five classes, according to the arms with which they are furnished. They are masculine in physique and dress, but not ferocious in appearance. The latest attack on Abbeokuta resulted in the loss and capture of nearly 3000 of the Dahomian soldiers, male and female. Dahomey daily loses prestige.

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Switzerland. In addition to these circumstances, it is highly probable that, during the icy period, the Gulf stream, at present so great a source of heat, did not visit our shores, but, owing to the different shape of North America, took an altogether different direction. The very imperfect state of our knowledge has given us as yet no proof of the existence of man during this period of extreme cold; though it has been ascertained that he flourished in Europe during an early part of the post-glacial period. Early education and tradition make it difficult for us to allow the long periods of time that must be granted for the changes which have taken place in the earth's surface. The geologic record is very fragmentary; and the more that is known of it, the more this fact is realized. In the lowest half of the series of Laurentian rocks, Dr. Dawson, of Montreal, has detected, by the aid of the microscope, the distinct structure of a large species of Rhizopod. The rocks in which this fossil—called the *Eozoon Canadense*—have been found, are as old, if not older, than any of the formations termed Azoic in Europe. Specimens have been brought to England by Sir William Logan, and are exhibited at the Association.

Thursday, September 15th.—In the section of Mathematical and Physical Science, Mr. GLAISHER read a paper on LUMINOUS METEORS. He said that numerous observations of fire-balls had been made. The largest had been seen on the night of the 5th December, 1863, and had produced a vivid impression of lightning over the whole of the British Isles. Fire-balls and shooting-stars are supposed to be loosely compacted, and in this way their want of penetrating power may be accounted for. Shooting-stars commence at 70 miles, and disappear at 50 miles above the surface of the earth. The meteors observed on the 9th and 10th of August, 1864, were in numbers nearly about the average of the phenomenon—namely, between 30 and 40 meteors per hour, for a single observer constantly regarding the sky near the zenith. They were not half so many in number as they were in 1863 on the corresponding dates. If any indication of periodicity can yet be traced in the fluctuations of this phenomenon, it is, perhaps, a minimum at intervals of eight years, which has thrice occurred, and on the last occasion in 1862.

PROFESSOR HENNESSEY read a paper on the ELLIPTICITY OF MARS. He said that the physical characters of the planet Mars have always been interesting on account of its supposed likeness in form to our own earth. In accordance with hydrostatical laws, a planet similar to Mars, and rotatory round its own axis in the same period of time, should have an ellipticity very nearly approaching that of our earth. Bessel and Johnson, observers of eminence, appear to have arrived at this conclusion, though some consider that the ellipticity of Mars is much greater. It is generally admitted that, in the neighbourhood of one of the poles of Mars, there exists a great mass of brilliant matter, analogous to a mass of terrestrial snow. This substance, if it is snow, must be situated on masses of land near the poles of rotation, and must vary in dimension as the seasons of the

planet alter. A fluid like water must exist in that part of the surface of Mars. Professor Hennessey said that, in controverting an erroneous theory of the earth's figure, he had obtained mathematical expressions for the equilibrium of a fluid like water spread over an exterior abraded spheroid, such as the earth was assumed to be. From these expressions it follows, that if the earth possessed very small ellipticity, it would consist of two circumpolar continents, with an intermediate belt of equatorial ocean; while, on the contrary, if the earth had great ellipticity, such as that assumed for Mars, the dry land would form an equatorial belt, while the poles would be surrounded with water. The attention of observers might be well directed to ascertaining which regions of Mars show the greatest predominance of dry land. Professor Hennessey's own opinion is, that no great amount of equatorial land exists in Mars, and that, therefore, the theory of its comparatively small ellipticity is the more probable.

On the same day, in the section of Chemical Science, the President, Professor Odling, gave some account of the recent agreement among English chemists, as to the combining proportions of the elementary bodies, and the molecular weights of their most important compounds. He said that Berzelius professedly regarded the single combining proportions of hydrogen and chlorine, as consisting each of two physical atoms; but since the two atoms of hydrogen, for instance, which constitute the one combining proportion of hydrogen, were chemically inseparable from one another, they were really tantamount to one atom only of hydrogen, and, as a matter of fact, were always employed by Berzelius as representing the single chemical atom of hydrogen, or its smallest actual combining proportion. Distinguishing thus, between the physical atom and the combining proportion, Berzelius' recognition of the truth, that equal volumes of the elementary gases contain an equal number of atoms, was utterly barren. But identifying the physical atom with the combining proportion, Gerhardt's recognition, or rather establishment of the broader truth, that equal volumes of all gases, elementary and compound, contain the same number of atoms, has been in the highest degree prolific. From Gerhardt's division of volatile bodies into a majority, whose recognized molecules corresponded respectively with four volumes of vapour, and a minority, whose recognized molecules correspond respectively with but two volumes, and from his proposals, in conjunction with Laurent, to double the molecular weights of these last, so as to make the molecules of all volatile bodies, simple and compound, correspond each with four volumes of vapour, must be traced the development of the matured views on chemical philosophy which now prevail. Professor Odling lamented the unsatisfactory state of chemical notation, and said that Sir B. Brodie was about to publish a plan which would be more suited to the present requirements of chemistry. He referred also to the study of isomerism, which, he said, is the chemical problem of the day, and said that concurrently with its rapidly advancing solution, will be the advance in rational organic synthesis—a subject which, at the present moment, seems to be making comparatively slow progress.

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rudders of vessels chased; there is no ship afloat which has sufficient strength to resist its power; it is characterized by great economy, simplicity, and safety in its working: and, in working it, neither the battery itself nor the men can be exposed, the apparatus being much below the line of flotation.

Saturday, September 17th.—In the section of Geography, a paper by Lord Milton and Dr. Cheadle attracted much attention. It described an expedition across the Rocky Mountains into British Columbia, through the Yellow Head Pass. With regard to the possibility of making a railway by this route, it is said to offer no engineering difficulties of any importance; the valley being in many places wide and unobstructed except by timber, and the flooding of the river by the melted snows not interfering with the passage of the valley. The reasons for preferring this route to any other yet opened are—1st. That it lies far removed from the boundary line, well within British territory; 2nd. That it passes entirely through a country inhabited only by peaceable and friendly Indians; and 3rd. That it offers the most direct communication from Canada to the gold regions of British Columbia, and from it the Sashwass and Okanagar districts, as well as the road on the Frazer, are easily accessible.

Mr. Bates' paper on The Delta of the Amazons stated that the delta was of a vastness commensurate with the size of the river itself. It forms a triangle, each side of which is about 180 miles, the mouth of the river being thus 180 miles in width. Within this gulf, the island of Marajo (as large as Sicily) divides the river into two channels, the northern, or Marie Amazons, 40 miles wide, and studded with islands, the southern, or Parà River, clear in course, and about 35 miles in width. The Amazon delta is not, as might be supposed, an unhealthy region of swamps. On the contrary, no part of it seems to be wholly due to fluvial deposit. In large areas the soil is sandy, with a rocky substratum; and, in several places, calcareous beds are found, containing an abundance of fossil marine shells. The country is healthy, and the temperature, though very high and uniform, is not so high as in many countries farther removed from the equator. The mean temperature in three years' observation was 81° Fahr. Singularly enough, a district, commencing at the western end of Marajo, and extending about 80 miles in length and breadth, presents all the characteristics of a true delta—a district composed of mud and sediment, intersected by deep channels. The conclusion arrived at is, that the true delta of the river is confined to the district just mentioned, now distant 140 miles from the sea, and that, at no very distant period, the seaward portion constituted a series of islands lying off the mouth of the river. This conclusion is borne out by observations made by Mr. Bates on the former of the two districts.

NOTES AND MEMORANDA.

FRESH EXPERIMENTS ON BACTERIUMS AND DISEASE.—M. Davaine has communicated to the French Academy another series of experiments on the propagation of disease by inoculating animals with blood containing the bacteriums which he affirms to be always present in spleen disease (*Sang de rate*). The bacteriums causing the disease he proposes to call *bacterides*, and so far from their being identical with bodies of somewhat similar appearance, which act as ferments of putrefaction, he finds his bacterides perish when the blood putrefies. He propagated the disease by causing animals to eat portions of the liver, or other viscus removed from creatures affected with the *Sang de rate*. Portions of putrid liver from healthy animals did not, when swallowed by others, produce anything like the mortality occasioned by pieces of non-putrid liver containing the bacterides. Females with young did not communicate the disease to their fœtal offspring.

THE SPECTRUM OF COMET II, 1864.—Professor Donati, of Florence, publishes in *Astron. Nach.* a sketch of the spectrum afforded by this comet, and he remarks that it resembles that produced by metals, the black bands being broader than the luminous.

SUPPOSED FIFTH SATELLITE OF JUPITER.—M. Camille Flammarion, writing in *Cosmos*, observes that M. de Gasparis, of Naples, saw on the 22nd July, at 7.59 p.m., a black well-defined point on the planet's disk. In a quarter of an hour this black point, moving in the direction of the planet's rotation, disappeared, passing from the margin. M. de Gasparis asks if this is the same body that has been seen by Messrs. Long and Baxendell. M. Flammarion says it could not have been a little planet in conjunction with Jupiter, for in that case its motion would have been in an opposite direction, and it was not one of the four known satellites, as they were all visible. Could it, he asks, have been a fifth small satellite?

SEEING VENUS NEAR THE SUN.—Mr. Dawes has an interesting letter in the *Astronomical Register* on this subject. He states that he could observe this planet within one minute of an arc of the sun's edge by employing a diaphragm, such as is used in his solar eye-piece. He recommends as a substitute for this diaphragm, a highly glazed address card with a needle-hole burnt through it. In such observations the planet should be viewed when a little way off the sun, with the lightest screen that enables her to be distinctly seen through the diaphragm, and with such a screen she may be followed nearly up to the sun's edge.

THE ALKALOIDS OF OPIUM.—M. Claude Bernard states, in *Comptes Rendus*, that out of the six proximate principles found in opium, only three, morphine, narceine, and codeine, produce sleep. Narcotine, papaverine, and thebaine, have no soporific properties. Morphine produces the most profound sleep. Codeine leaves the nervous system excitable, and when the animal awakes up from its action it is in a natural state, not frightened and scared as by morphine. Narceine produces sleep in smaller doses than codiene, and the sleep is sounder, but not so leaden as when morphine is employed. There is also an absence of excitability by noises which is noticeable in morphine sleep, and still more so in that of codeine. The awakening is natural. M. C. Bernard recognizes three properties in these alkaloids—soporific, convulsing and exciting, and poisonous. In soporific power narceine stands first, then morphine, then codeine. The convulsive series runs,—1, thebaine, 2, papaverine, 3, narcotine, 4, codeine, 5, morphine, 6, narceine. The poisoning properties are shown in the order, thebaine, codeine, papaverine, narceine, morphine, narcotine.

POISONING FROM CONTACT WITH TOBACCO.—M. Namias communicates to the French Academy the case of a smuggler who suffered under strong symptoms of tobacco poisoning, through hiding under his clothes, and all over his body, in contact with his skin, a quantity of the leaves of that plant.

RESPIRATORY NERVES OF INSECTS.—M. E. Bandelot has communicated to the French Academy the results of his experiments. M. Faivre had asserted that amongst insects of the Dyticus sort, the metathoracic ganglion excites and

co-ordinates respiratory movements, and acted as their point of departure. The posterior abdominal movements that assist respiration he referred to the subœsophagal ganglia, and regarded the abdominal ganglia, which are the origin of respiratory nerves, as merely conductors, connected with the respiratory centre, and unable to continue respiration after connection with those centres ceased. M. Bandelot doubted these conclusions, and selected for his researches the larva of the dragon fly, as being easier to experiment with than a Dyticus. The dragon fly larva has no separate ganglia, the metathoracic being connected with the first abdominal ganglion by long communications. Having removed the head of this larva at noon, the respiration continued regularly to six o'clock. The next day it went on feebly at nine o'clock, and only stopped about three. In a second experiment he divided the body immediately behind the metathoracic ganglion; but respiration continued. From these and other experiments he concludes that M. Faivre was in error, and that instead of there being only one centre of respiratory action, each abdominal ganglion acts as the local centre, and combines with others to produce a co-ordinated result.

Formation of Ice in the Sea.—M. E. Edland treats of this question in *Poggendorff's Annals*, and he states that in addition to the mode usual in fresh water, in which the surface freezes first, and if the cold is prolonged the layer of ice is thickened, it is common in the open sea for a great mass of water to be reduced below the freezing point without losing its liquidity, and for it then suddenly to solidify all through.

Physical Analysis of the Human Breath.—Mr. W. F. Barrett, Assistant in the Physical Laboratory of the Royal Institution, has recently published, in the *Philosophical Magazine*, a new and extremely delicate method of determining the amount of carbonic acid in air expired from the lungs. The apparatus used by Mr. Barrett in this investigation, which has been made under the general direction of Professor Tyndall, is nearly the same as that employed by the Professor in his researches on the absorption of heat by gases.

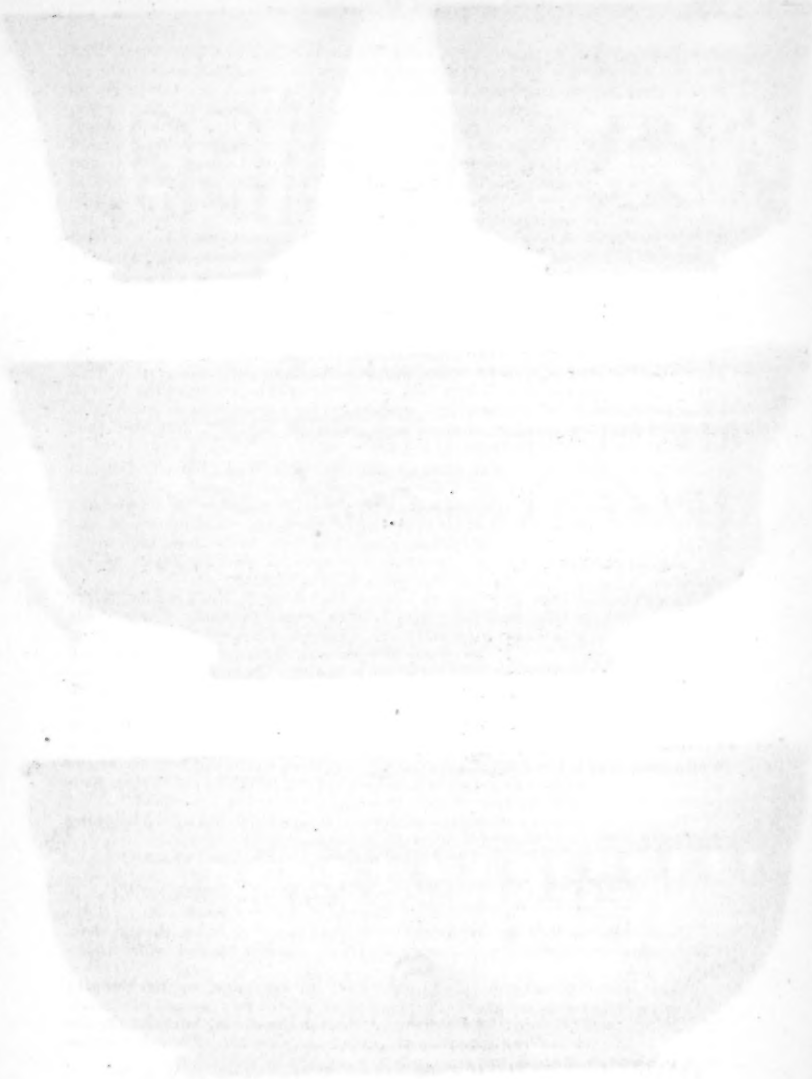
Three suitable bags are filled with the human breath; No. 1 is filled *before* breakfast; No. 2, *after* breakfast; No. 3, after severe exertion. The contents are then successively allowed to enter an exhausted brass cylinder, the ends of which are stopped air-tight by plates of rock-salt. Through this cylinder the radiation from a flame of carbonic oxide gas is passing. Immediately the breath, which has been deprived of its moisture, fills the brass cylinder, more than half the heat from the flame is cut off, or absorbed, and this entirely by the small quantity of carbonic acid present in the expired air. The amount of heat intercepted by the breath is, in each case, accurately measured by means of a delicate thermo-multiplier. The per-centage of carbonic acid contained in the different specimens of breath is found by calculation and subsequent experiments, and is then compared with a chemical analysis of each specimen made by Dr. Frankland.

The close agreement between the methods of analysis is shown by the following numbers:—

	By physical analysis.	By chemical analysis.
Bag 1.	4·00	4·31
Bag 2.	4·66	4·56
Bag 3.	5·33	5·22

These numbers indicate the per-cent. of carbonic acid in breath, and show that in these experiments the least amount of that gas was exhaled before breakfast.

Many other different samples of breath have been examined by Mr. Barrett; the results he has obtained prove the great delicacy ot the new method of analysis in detecting small quantities of carbonic acid, or in discovering variations in the amount of this gas in the atmosphere or in the human breath. For this purpose its application in hospitals has already been suggested by eminent men.



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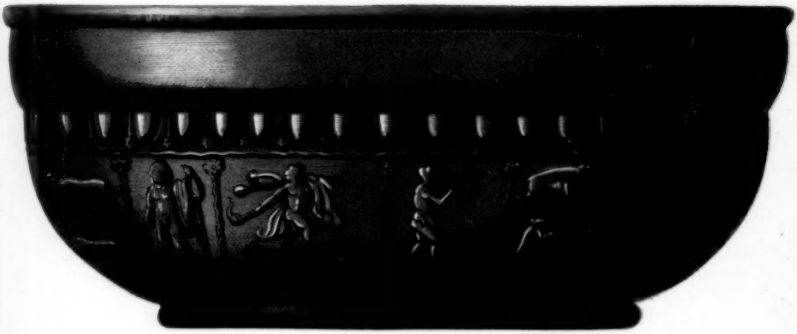

Roman Samian Ware.